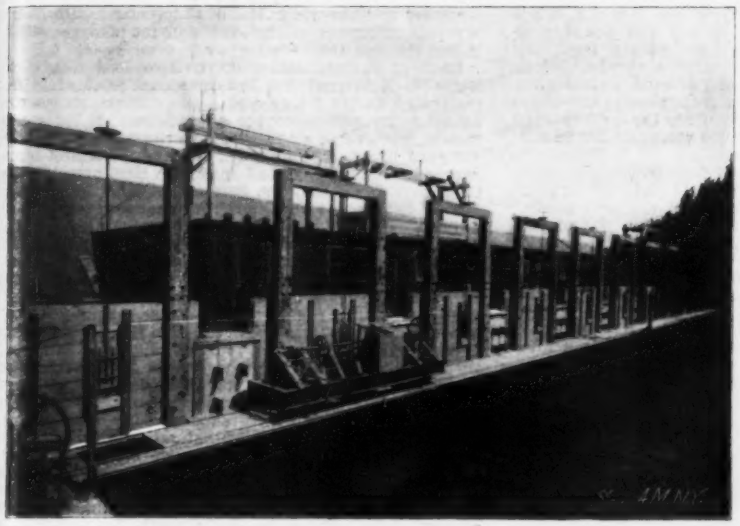
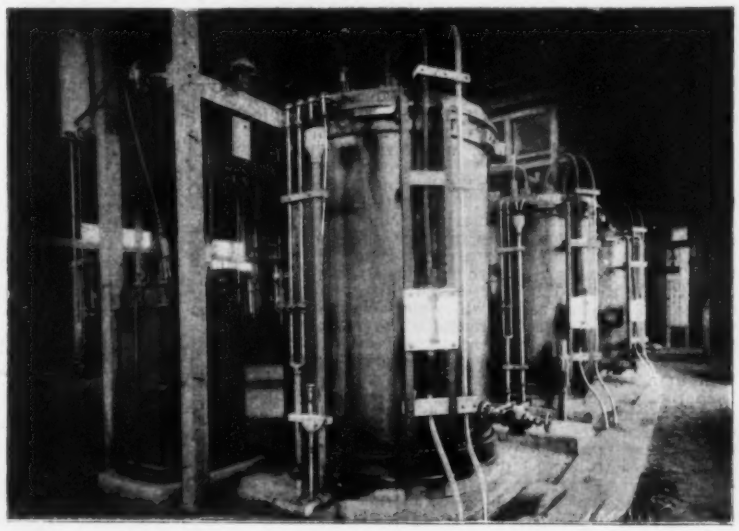
SCIENTIFIC AMERICAN SUPPLEMENT. No. 1398

Copyright, 1902, by Munn & Co.

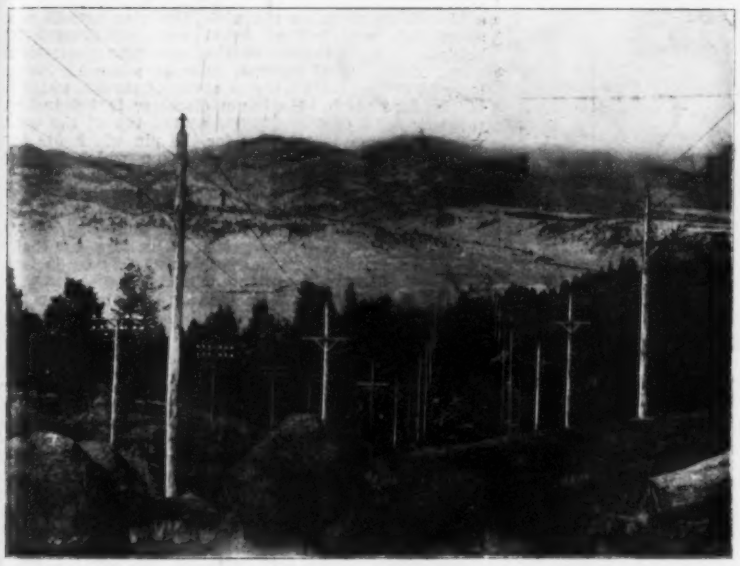
Scientific American, established 1845.
Scientific American Supplement, Vol. LIV, No. 1398. NEW YORK, OCTOBER 18, 1902. Scientific American Supplement, $5 a year.
Scientific American and Supplement, $7 a year.



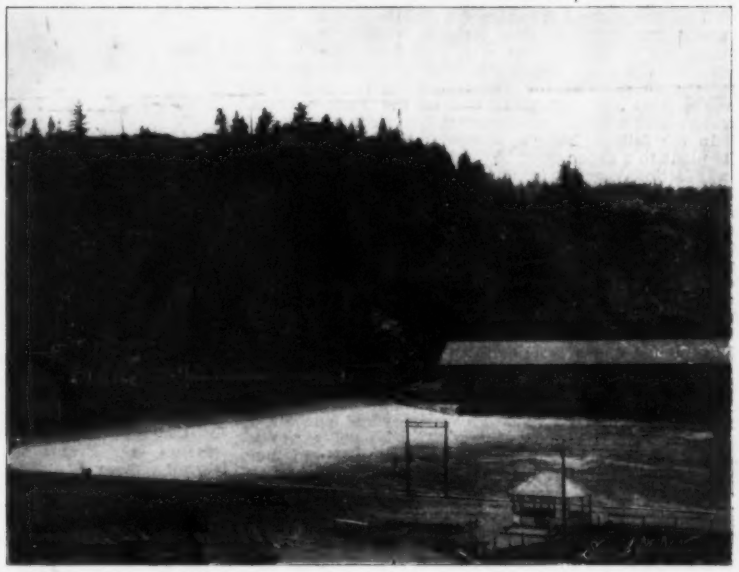
MAIN GATES, SHOWING LIFTING GEAR AND RACKS.



A BANK OF TRANSFORMERS IN THE BUTTE SUB-STATION.

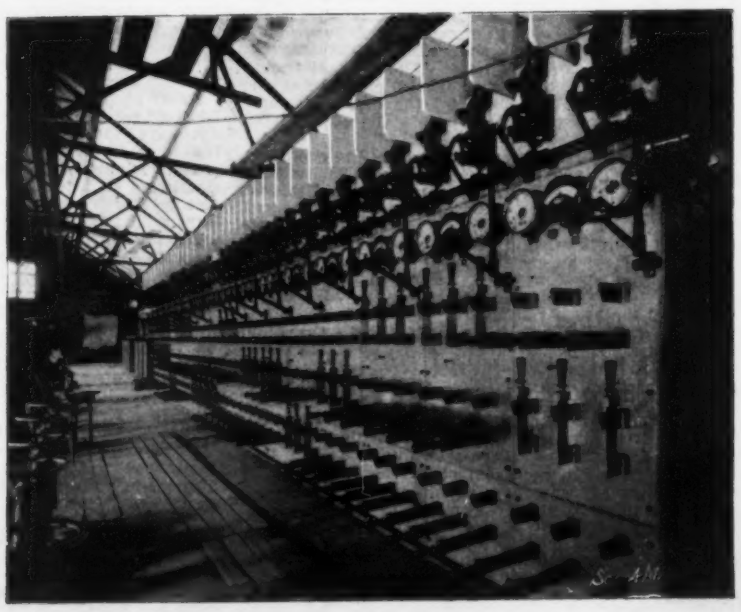


POLE LINE ONE MILE EAST OF POWER STATION, SHOWING DOUBLE POLES ON THE 50,000-VOLT BUTTE TRANSMISSION. TO THE LEFT THE 12,000-VOLT LINE TO HELENA.



VIEW FROM EAST SIDE OF MISSOURI RIVER, SHOWING POWER HOUSE.

INTERIOR OF POWER HOUSE AT CANYON FERRY.



SWITCHBOARD AT CANYON FERRY.

ELECTRIC POWER INSTALLATION NEAR BUTTE, MONTANA.

ELECTRIC POWER INSTALLATION NEAR BUTTE, MONTANA.*

The first long-distance transmission line of electrical power in the United States was established in California, but to Montana belongs the credit of having the first transmission line of a high potential—that of 50,000 volts. Several plants in the country have proposed to use a higher voltage than 40,000, but the Missouri River Power Company is the first to place that potential in actual service.

The above company, known as the Helena Water and Electric Power Company, in 1898 commenced work upon its present power station located on the Missouri River at the mouth of what was then known as Black Cañon, some 18 miles east of Butte, Montana. At this point a dam 480 feet in length was built across the river, giving a 30-foot head and impounding a sheet of water some 7½ miles in length by 2¾ miles wide, this giving sufficient power to develop 10,000 horse power the year round. The power house at this time was built of rock-faced granite 225 x 30 feet inside measurement, and 28 feet in the clear below the trusses of the roof. A steel and corrugated iron arch gallery was built along the west side 17 feet 6 inches wide and 13 feet 6 inches clear below the roof trusses. This gallery extends across the north end of the power house, on which are the company's offices. The space between the edge of this gallery and the east, or river, side is covered by an electric 15-ton crane which is used in repair work on generators, etc. All the steel work, as well as the crane, was furnished by the American Bridge Company.

The original installation at this time consisted of four two-phase kodel type 750-kilowatt 550-volt generators, direct connected by flexible couplings to pairs of Dayton Globe Iron Works turbines, three of these being controlled by Replogle governors and the fourth by a Type B Lombard governor. There were also in place two 90-kilowatt 125-volt exciters direct connected to separate turbines and a white marble switchboard with four sets of buses through which current was carried from the four transformer panels over sixteen lead-covered cables of 1,000,000-centimeter capacity each to a transformer house built a short distance from the station. In this house were eight 325-kilowatt transformers, oil-insulated and self-cooled, connected in four sets in the Scott two-three-phase system transforming from 550 volts to 11,000 volts. Current, at this pressure, passed through a plug board, Westinghouse Type R arrester and into the four feed lines of No. 4 solid copper which led to another plug board of similar construction at the substation at East Helena. At Helena the current was used, after transforming to 2,200 volts, for driving induction motors which were direct connected to arc light machines as well as for general incandescent lighting. Two large rotary transformers also supplied current for the street car system in that city. At East Helena current was used for power purposes in a large smelter located there, and for generating lights about the works, also for furnishing one of the Peck concentrators and a large ore-concentrating plant.

In the fall of 1900 the company decided to enlarge its plant to a capacity of 10,000 horse power by putting in additional generators, exciters, transformers and the necessary supplies, and to extend the service to Butte, Montana, to furnish current to a large number of the smelters and mines for which this town is famous. In addition to the main power house a steel and corrugated iron annex 150 feet long was built, occupying the space between the power house and canal wall, having its floor just above the penstocks and on a level with the gallery floor, and the company here installed six three-phase 750-kilowatt 550-volt Westinghouse generators direct connected by flexible couplings to pairs of 45-inch turbines furnished by the S. Morgan Smith Company, and one 225-kilowatt 150-165 exciter connected to another turbine of the same make, six Type B Lombard governors and one Type B governor, another exciter 150-kilowatt capacity driven by 150 horse power Type C 550-volt induction motor. Six 950-kilowatt 550 to 50,000-volt transformers, together with twelve static interrupters, six lightning arresters, and fused circuit breakers, were also installed. This equipment of transformers, etc., was duplicated in the Butte sub-station. These twelve transformers at the present time can be connected with 550-volt or 2,200-volt to 25,000-volt or 50,000-volt with extra strips for forming adjustment to meet running conditions of the plant. The four original generators were changed from two-phase to three-phase by the addition of brass fish-plates to stiffen the laminations at each end of the armature, and new ventilated-type three-phase collector rings were substituted for the original two-phase rings. The original transformers and plugboards were moved onto the main gallery of the power house, and the arresters were placed in the annex, where also were placed the new transformers mentioned.

The old switchboard was discarded by the company and an entirely new one of Vermont marble finished in polished copper and black enamel, 47 feet 4 inches x 9 feet 9 7-16 inches, was located centrally on the gallery. At the left of the board are six 325-kilowatt 550 to 11,000-volt transformers in two groups. At the right was placed an exciter board of four panels with two pairs of buses, next six more transformers like those on the left, and lastly a four-panel plug-board to control the 11,000-volt output of these twelve transformers, and distribute it as desired onto the four feeder lines mentioned. From either end of the main switchboard the arrangement is:

Five generator panels, each carrying one field ammeter, one alternating-current ammeter and one long-scale polyphase wattmeter, two circuit-breakers, nine 1,200-ampere U-blade switches, synchronizing lamp of 5 candle power and synchronizing plug.

Two feed panels, each controlling three of the 325-kilowatt transformers and equipped with three ammeters connected to three 5-ampere series converters directly in the circuit of each transformer, three circuit breakers and nine 2,000-ampere U. B. switches.

One feed panel similar to the last two, but equipped for 3,000 amperes per leg, and controlling three of the 950-kilowatt 550 to 50,000-volt transformers.

The eighth panel from either end is a junction panel equipped with 4,000-ampere U. B. switches for joining the halves of the three sets of buses, and on its upper section carrying six polyphase indicating wattmeters, one connected to each feeder circuit.

The nine separate bus-bars are built of ⅛-inch x 3-inch rolled copper, the number of strips in each bus increasing gradually from six at the outer ends of the board to thirty strips opposite the fifth generator panel. Small marble panels in front of the main board on the I-beam carrying the crane rail furnish a mounting for field switches and voltmeter plugs and six polyphase integrating wattmeters connected to the feeder circuit. Directly below the field switches are the corresponding rheostat pedestals connecting to base plates, and hung below the gallery floor; the rheostats with cast grid of Type B being also mounted below the gallery floor. There are four voltmeters swinging at each end of the board, three for each half of the set of bus-bars, and one throwing-in voltmeter for the five generators on each half. The alternating-current indicating instruments are all long scale, and are of exceedingly high range; all switches are of the latest unit blade type of very ample capacity, while current density of buses and cables was nowhere allowed to exceed 500 amperes per square inch. All circuit-breakers are non-automatic air-brake, Brush type, of very ample capacity and of easy operation.

During the period of change from the old two-phase to the new three-phase switchboard, the two systems were run in parallel on the 11,000 volts side for several days with perfect satisfaction.

From each of the four small feed panels six 1,000,000-centimeter lead-covered cables lead through an open cableway level with the top of the switchboard, directly to the 325-kilowatt transformers, the circuit-breakers on the board being connected each in one leg of a transformer, as are also the ammeters.

From the high-tension side of the transformers, No. 4 9-32 rubber-covered units lead straight up to a cross-arm on the roof trusses, thence distributing to the proper wire of twelve buses which are supported on the roof trusses, and lead down to the 11,000-volt plugboard at the extreme right. In the various changes necessitated during construction, these buses were proven very convenient for facilitating the movement

INSULATOR AND SLEEVE PIN ASSEMBLED.

of transformers, changing from two-phase to three-phase, etc. From the plugboard current passes through Type R lightning arresters in the annex of the power house and thence straight up through 2-inch x 36-inch glass tubes which are supported by the nearly flat roof. The insulation here consists simply of rubber-covered wire drawn through split wooden bushings; the tubes are surmounted by 12-inch conical galvanized caps tapped to a water-tight joint next to the wire. The wooden bushings are flashed next to the roof to form a water-tight joint and are bolted to the roof by lag bolts. The 550-volt leads are brought out through the roof in an entirely similar manner, glass tubes 2 inches x 48 inches with a light cone of heavy waterproof canvas and a dry wooden frame with a base diameter of 18 inches being used for a protection from moisture.

From each of the two large feed panels eighteen 1,000,000-centimeter cables lead through convenient doorways, pass along the wall of the addition, and thence span a distance of about 5 feet to the low-tension terminals of the 950-kilowatt transformer sets. One leg of each transformer can be opened by the circuit breakers on the main board, the other by switches located in the doorways mentioned above. The high-tension leads of the transformers pass first through static interrupters, then through fused circuit breakers on one leg and a plain knife switch on the other leg, thence connecting to three heavy rubber-covered bus-wires overhead. The outer end of each of these buses connects through fused circuit breakers, with one of the two three-wire lines to Butte. The inner ends may be tied together by similiar fused breakers. Thus either transformer set may feed either line, or both may be fed in parallel or separately. Also, any transformer may be entirely cut out by opening both high-tension and low-tension lead, without interrupting the service.

The static interrupters are comparatively novel. Their use and theory are fully described by Mr. Thomas in a recent paper before the A. I. E. E. They consist essentially of a choke coil in series with the transformer lead, and a condenser connected from the transformer side of the choke coil to ground, the whole being immersed in oil. The ground current from this condenser has been put to a novel use by the electrician of this company. The Western alternating-current voltmeter is used as an ammeter, connected in the ground circuit of the condenser to determine the condition of transformers and attached line relative to ground; the induction being fully that of the dynamic current, many bothersome features of the ordinary static inductor are avoided. There are, of course, sources of error, but they do not prove troublesome. The main transformers are water-cooled, but the coils being about 5 feet above the level of the water of the forebay it was necessary to have recourse to pump circulation or some form of siphon. Main intake pipes in duplicate, supplied with proper strainers, were brought in through the canal wall below low-water level. The transformer coils were bridged between there and other pipes leading 30 feet down to the tail races. These intake and discharge pipes were connected by a valve which allows water to flow directly through the discharge pipe, thus starting a vacuum. This valve is then closed, and water is immediately siphoned through the transformers. A common vacuum gage shows the conditions as to vacuum, while in the discharge pipe of each transformer a small brass venture 12 inches long, ⅜-inch small diameter and 1½ inches large diameter, having a single mercury U-tube connected between the central small diameter and the upper end of the venture, affords an accurate indication of the exact amount of water circulating through the transformer.

Each of the six cables of the two feeder lines to Butte is protected by low-equivalent lightning arresters at Cañon Ferry and Butte. These cables are of seven strands of copper aggregating 106,500 centimeters, each cable mounted on special glass insulators designed by M. H. Gerry, Jr., chief engineer and manager of the company, and made by Hemingray Glass Company, Covington, Ky.

The distance of the line from the power house at Cañon Ferry to Butte is 65 miles, paralleling as nearly as possible the Northern Pacific Railway. At its start the line has an altitude of 4,000 feet above sea level, and in passing over the Great Divide a few miles east of Butte it reaches an altitude of 7,300 feet.

The pole line consists of one line to the city of Helena and two lines to Butte, the Helena pole line leaving Cañon Ferry as four circuits consisting of three wires each, of No. 4 bare copper wire. This line has a potential of 12,000 volts. To Butte there is a double pole line, each carrying three seven-strand copper cables having an area of 125,000 centimeters. Cables are arranged in an equilateral triangle of 6 feet 6 inches apart and mounted on special glass insulators. The working capacity of the line is 50,000 volts. The insulator proper is three-petticoated glass 5⅜ inches high and 9 inches diameter, the pin extending as nearly as possible to the wire groove below the insulator; and extending up inside the inner petticoat is a tapered glass sleeve 5½ inches diameter at its lower end, clearing the cross-arm by 1¼ inches, and supported on a ¼-inch shoulder on the pin. The pins are all seasoned oak, still further dried, and impregnated by boiling in hot paraffin, so that the pins themselves stand 100,000 volts on test. The pins are 12 inches long above the bars, 1¼ inches at top of thread, which is of standard pitch. Maximum diameter is 2½ inches, tapering on a 60-degree angle at the top of the butt, whose diameter is 2 inches for the pin which fits the cross-arm and 2¼ inches for the pin which fits the pole tops. These latter butts are 8 inches long, and the former 5½ inches; a special reamer insures a close fit in the top of the pole and the cross-arm.

The pole lines are 40 feet apart and the path is entirely cleared of trees, etc. Poles are of Idaho cedar, 8-inch tops, in lengths from 35 feet to 90 feet, all poles above 75 feet being spliced.

The telephone line is located on one line of poles, whose wires are about 4 feet below the last power wire. This circuit has given excellent service, working perfectly under all conditions of weather.

The Butte sub-station is a steel and corrugated iron building 60 feet x 80 feet x 20 feet studs. The feeder lines entering one end through glass tubes 2 inches x 48 inches pass through a dry wooden panel and are protected from the weather by a shed roof overhanging about 5 feet. The low-equivalent arresters, fused line breakers, paralleling breakers and breakers on each leg of the six 950-kilowatt transformers, together with the static interrupters, are practically a duplicate of the equipment at Cañon Ferry. The arresters, line and tie breakers are at the end of the building, and transformers along each side of the central court toward which all breakers open. The main switchboard consists of two 40-inch by 9-foot 9-inch panels with three circuit breakers, three ammeters and six knife switches, each connecting the low tension (2,200 volts) of the transformers to either or both of two bus sets, and, as at the generating station, the switchboard circuit breakers open one leg of each transformer circuit, while knife switches mounted on each transformer case open the other leg. These transformer cases are very substantially built of heavy boiler steel, with cast iron and walnut covers bolted on, and hold about sixteen barrels of I. S. C. transformer oil each. A pair of synchronizing lamps and a swinging voltmeter are provided. Integral with these two panels on either side are panels 20 inches wide on which are mounted the sets of feeder instruments, three ammeters and one polyphase indicating wattmeter. These feeder circuits feed out through three-pole double-throw General Electric oil switches to bare stranded cables of 600,000-centimeter section, leading to the company's various loads in Butte.

There are at present three of these feeders, and the switchboard instruments are provided with an unusually ample range, so as to read motor starting and even short-circuited currents. All feeder wattmeters take their series currents from three 5-ampere series connected directly in each transformer circuit, the three currents being combined into two circuits of 8.6 amperes each at full normal load, through the two coils of the wattmeter. The shunt circuits are fed from auto-connecters at Cañon Ferry, and shunt transformers at Butte. These meters have a very long and uniform scale, and are intended to be very accurate under all conditions. Generators and wattmeters at the Cañon Ferry generating plant are also of the polyphase type, but are connected according to the more common scheme of two wattmeters on three-phase circuits.

As before stated, all electrical apparatus is of West-

* Specially prepared for the Scientific American Supplement.

inghouse make, except a few oil circuit-breaker switches at Butte. Nearly all consuming apparatus at Butte, however, is General Electric. This apparatus, aside from incandescent lighting for the mines, consists entirely of induction motors from 25 to 50 horse power and 300 horse power to 800 horse power capacity, there being at the present time only one of the latter size, which drives the largest mine air compressor in the world at full load constant. The most of the motors are from 50 horse power to 300 horse power capacity, and are equipped with rope drive, some of the smaller ones being direct connected to 500-volt alternating-current generators furnishing direct current for mines, mine trolley cars, etc.

One feature of the plant which deserves notice is that since the starting of the original installation no mishap of any kind either to the generating plant, transmission line or sub-stations has occurred; this is something out of the ordinary, taking into consideration the style of plant with its high potential and the country through which it runs.

ELECTROLYTIC MANUFACTURE OF ZINC.

THE first attempts at the electro-chemical treatment of zinc ores occurred scarcely twenty years ago. Since that time there have been numerous undertakings, but the results have not fulfilled expectations; so at present some of the processes worked are far from being perfect.

It may be remarked that various difficulties are met with in the preparation of electrolytic zinc, and that it is wellnigh impossible to obviate them. The two principal permanent obstacles are, one purely mechanical, the other connected with physico-chemical considerations. These are the difficulty of obtaining the metal in a compact form, and that of decreasing the polarization by overcoming the counter-electromotive force.

When a zinc salt is electrolyzed under suitable conditions the metal tends to be deposited at the cathode in a spongy and grayish form. This "sponge" as it is called cannot, whatever the means employed, be collected in a compact mass.

Siemens attributes the formation of zinc sponge to nascent hydrogen, which is formed around the cathode. The hydrogen, according to the author, would form a hydride of zinc, communicating to the deposits the spongy appearance and dull gray color. Independently of this consideration it is also ascertained that the presence of foreign metals, as well as the greater or less acidity of the solution, exercises a certain influence on the formation of spongy zinc.

Foerster and Gunter are of a different opinion from that of Siemens, and think that the formation of zinc sponge is due to the formation of zinc oxide, precipitated at the cathode.

The polarization is an inconvenience not less serious, since it annihilates a marked proportion of the electric energy brought into action. Of nature essentially physico-chemical, it may be more or less combated by modifying the degree of concentration, of acidity, and the temperature of the electrolytes; or by creating within the liquors secondary reactions capable of opposing its formation.

These different methods have been utilized in turn in the numerous processes contrived for the electrolytic production of zinc. The first serious attempt was made in 1872 by Mijers. At that time he prepared large quantities of zinc by making use of a solution of zinc sulphate and sal ammoniac, which he afterward submitted to the action of the electric current. The positive electrode consisted of a plate of zinc, and the negative electrode of a piece of copper in the form of the letter T. The current was furnished by two Bunsen elements. Under these conditions the piece of copper was rapidly covered with a layer of zinc, while at the extremities of the T appeared arborescent crystallizations of the metal. In truth, this was only a laboratory experiment. The first and real industrial application dates from 1881. The inventor was a Frenchman, Lambette-Doucet. He attacked previously roasted blende with chlorhydric acid or chlorine; by washing he obtained concentrated liquors, from which he eliminated the iron by the aid of oxidants, such as chlorine, nitric acid, manganese bioxide or nitrates. Then he submitted the liquor thus purified to electrolysis, with anodes of charcoal or of agglomerated manganese bioxide, and with cathodes of zinc. The process was worked by the inventor for about two years. It was then abandoned, for the results proved to be unsatisfactory; in fact, the resistance of the electrolyte was enormous. Very frequently the agglomerates were disaggregated, and the diaphragms of paper or parchment were rapidly attacked by the chlorine. The Letrange process, patented in July, 1881, indicated a certain progress, and showed that this inventor had comprehended the problem better than Lambette-Doucet, although the results furnished were still moderate. Nevertheless, this process has maintained celebrity; all the treatises of chemistry give it a prominent mention, for it really marks the commencement of the electro-chemical industry of zinc.

In the Letrange process the blendes were first roasted at a low temperature, for the single purpose of converting them into zinc sulphate and oxide. Then they were submitted to a methodical lixiviation with dilute sulphuric acid, in reservoirs of mason work lined with asphalt and communicating together. The solution obtained, neutralized by calamine, was electrolyzed after the iron had been eliminated. Letrange employed as cathodes thin leaves of zinc, of copper, or of polished brass; the anodes were of platinum, lead or charcoal. The electrolytic vats consisted of long basins, separated in the interior by porous partitions, between which alternated the anodes surrounded with the ore, and the cathodes. When the liquors became acid they were evacuated by pipes and served for the extraction of new quantities of ore. When the cathode was covered with a deposit of zinc of 5 millimeters it was removed and scraped.

Letrange conducted this process in two of his factories, at St. Denis and in the Var. The results at first appeared favorable; the expenditure of charcoal was only 2.100 kilogrammes per kilometer of zinc produced, while the metallurgic processes in use necessitated the employment of 2 kilometers of reducing charcoal and 9.8 kilometers of heating charcoal. But this advantage was of no real value when the various inconveniences inherent to the process were considered, the rapid disaggregation of the charcoal anodes, frequent breakage of the porous partitions in consequence of the pressure of the ore, and especially the great loss of time in taking out, scraping and changing the cathodes. Besides, experience had demonstrated that 2.6 horse power were necessary to liberate 1 kilogramme of zinc, while by the Letrange method 4 were necessary. Still the process, however moderate the results, exhibited courage on the part of the inventor at a time when electro-metallurgy was in its infancy.

The same year as Letrange a German, Luckow, endeavored to suspend in a bath consisting of a concentrated solution of zinc chloride a mixture of blende and coke in open-work cases. The results obtained were defective, and the process was abandoned almost without application.

Kiliani (1883) was the first who engaged resolutely in the electrolytic preparation of pure zinc. He sought to study thoroughly the condition in which spongy zinc was formed and to avoid this production. This process was far from being perfect, but the inventor achieved a real advance over his predecessors. Kiliani, in the course of his researches, ascertained that by employing concentrated solutions and intensity of current, varying with the degree of concentration of the electrolyte, compact zinc was obtained, and that no hydrogen was disengaged at the cathode. The different experiments which he undertook for this purpose led him to advise the employment of solutions of zinc sulphate of the density 1.38 and electrodes of zinc.

It was also in 1883 that two other Germans, Blass and Miest, attempted a series of arrangements, the foundation of which was the same for all, but which did not realize good results. Blass and Miest neither roasted nor lixiviated the ore. The electrolyte consisted of a nitrate, in which the ore was put either inclosed in sacks or agglomerated, or even simply kept in solution. In these conditions it is easy to understand that reactions were produced, and the sulphur collected in considerable and troublesome deposits around the cathode. It was also quite difficult to take cognizance of the precise moment when all the metal was deposited, and consequently the end of the operation. Finally, the pressure furnished by the grains of ore was far from being sufficient to produce a suitable contact. In addition to these numerous inconveniences the manipulation was quite costly, in consequence of the emptying and filling of the vats, and it can be easily comprehended that the authors soon abandoned the process.

Marchèse and then Thiollier tried similar arrangements in sheet iron cases or by mixing with charcoal. But they were not more fortunate than Blass and Miest. Rösing connected the ore at the positive pole and employed as an electrolyte a solution of sea-salt constantly renewed.

Many different attempts followed until 1892, but without success, and it is only from that year that the results obtained were important.

We have seen from the outset that one of the principal difficulties encountered by different inventors was the effort to overcome the counter electro-motive resistance resulting from the polarization.

In 1892 Cassel and Kjellin, of Stockholm, in consequence of their study of the electrolysis of zinc, advised the employment of ferric sulphate as a depolarizer. They employed as a cathode a plate of zinc, and the anode, of iron, was separated from the cathode by a porous partition. The compartment of the cathode contained zinc sulphate; that of the anode, iron sulphate.

The process of Cassel and Kjellin was of great importance in the history of the electro-metallurgy of zinc, for many inventors have taken advantage of it, modifying it to suit their ideas. It possesses valuable features, and the idea on which it is based is ingenious. The inventors are quite satisfied.

In truth, the employment of soluble anodes is designed to prevent the disengagement of hydrogen and oxygen during the electrolysis, while retaining the acid set at liberty. From this fact the difference of potential is considerably lowered. The only important criticism to make is the employment of partitions of porous clay.

Inspired with the same ideas, Siemens, who has been justly styled the pioneer of electrolysis, advised in 1892 the treatment of the zinc salts, sulphate or chloride by a ferrous salt in presence of insoluble anodes, and non-porous diaphragms, allowing merely the passage of the current without allowing the solution to pass.

The reaction which takes place is the following:

$$SO_4Zn + 2SO_4Fe = Zn + Fe_2(SO_4)_3.$$

The ferrous salt is converted into ferric salt, which has the property of dissolving the zinc of the roasted blendes and forming zinc sulphate and ferric sulphate, which may thus serve indefinitely:

$$ZnS + (SO_4)_3Fe_2 = SO_4Zn\ 2FeSO_4 + S.$$

Pursuing their researches the brothers Siemens, setting out from this idea that the formation of spongy zinc was due to the compound ZnH_2, arising under the action of the nascent hydrogen at the cathode on the metallic deposit formed, sought to absorb the hydrogen for the purpose of avoiding the formation of spongy zinc. The halogens were all indicated for this purpose, and the authors advised the addition to the solution of the zinc sulphate, of either a weak solution of chlorine, bromine or iodine, or of a solution of hypochlorous or hypobromous acid; or to saturate the gaseous chlorine or bromine, the electrolyte, or to add to it organic products of substitution of the chlorine, such as the chlorhydrines of glycerine and of other glycols. The quantities of these bodies to be employed were relatively small and had no influence on the cathodes, but the indispensable condition of success was that the electrolyte should always present the reaction of the free halogen or the halogenized combination. The metal obtained presents a fine silver-white color and never the appearance of the gray zinc sponge.

In the course of their laborious researches the brothers Siemens remarked that if a rapid movement of circulation were communicated to the electrolyte the formation of spongy zinc would be avoided. As an agent of circulation they utilize the air under pressure. This, forced by a pump, is introduced into the vats in the lower portion and determines within the liquid a continuous ebullition. The cathodes of zinc are separated from the anodes of charcoal or of lead by wooden partitions, reaching neither to the bottom of the vats nor to the level of the surface of the liquids. The air, under pressure, coming from below through a perforated pipe, causes the liquid to ascend above the partitions, thus communicating a movement of circulation of which the rapidity can be regulated at will. This current of air has also the advantage of oxidizing the impurities of the bath. The electrolyte consists of a solution of zinc sulphate of 10 deg. B., with the addition of 5 to 10 grammes of sulphuric acid per liter. The quantity of air is one cubic meter per hour and per cathode.

Hoepfner, in 1894, indicated a similar process. He employed as electrolyte a solution of zinc chloride, purified and freed from foreign metals. The cathode was fixed to an arbor revolving at a certain velocity, and thus communicating to it a rotary movement more or less rapid.

The success obtained by Siemens encouraged manufacturers and inventors, and every year numerous patents were taken out.

In the first place came that of Otto Lindemann, which consisted in employing a solution of zinc sulphate holding zinc sulphide in solution. The solution of zinc sulphate marked 37—38 deg. Bé., and was first freed from metals precipitable by zinc. It was contained in a cubic vessel lined with lead. The solution of hydrogen sulphide was saturated, the zinc sulphate was precipitated and fell to the bottom. When the volume of the precipitate ceased to increase, that is, when it reached one-third or one-fourth of the height of the vessel, it was poured off and the decanted liquid replaced with a neutral solution of zinc sulphate. Then it was submitted to electrolysis while keeping the zinc sulphide in suspension by the aid of agitators, which communicated at the same time to the electrolyte a rapid movement. This process certainly presents an interesting feature in this respect, that the zinc sulphide in suspension exercises an influence on the state of aggregation of the metal, but it does not prevent the enrichment of the liquor in sulphuric acid; zinc sulphite ought to be added from time to time.

The process of the Electricität Aktien-Gesellschaft, which also dates from 1894, does not employ diaphragms. It consists of electrolyzing a solution of zinc hydrate in the chloride or sulphate of zinc, or in a mixture of the two, at temperatures embraced between 50 deg. and the boiling point of these liquids. The solutions, neutral or slightly acid, of zinc chlorides are kept at the boiling point for ten minutes, then electrolyzed hot with a current of 100 amperes per square meter of electrode. The zinc is deposited in a compact form, adhering to the cathode, while oxygen is disengaged at the insoluble anode.

The Ashcroft process (1896) exploited by the Sulphide Corporation, is quite similar. It consists in adding to the electrolyte the oxy-salts which absorb the chlorine and the sulphuric acid set at liberty. The metal thus obtained is compact. To form the oxy-salts zinc oxide is added to the hot solution; the electrolysis takes place cold.

Lorenz, in 1896, indicated a process which allows avoiding the formation of spongy zinc by electrolyzing zinc chloride, melted at a temperature sufficiently high. The tension is thus sensibly diminished. The chlorine, which is disengaged at the anode, passes over coke at the red, thus producing chlorhydric acid, which serves to lixiviate new quantities of the ore. This process presents a practical and industrial side of real value.

Lately the question of the electrolytic preparation of zinc has again been the object of important researches. These have received many applications, but they are now nearly all abandoned. They resemble each other in their principal features, differing only in the nature of the solvent of the ore or in the construction of the electrolytic apparatus.

The most important of these processes are those of Ashcroft, Siemens & Halske, Dieffenbach, Nahnsen, Hoepfner and Swinburne.

The Ashcroft process, purchased by the Sulphide Corporation, was worked in 1897 and 1898 in New South Wales and in Essex, England. The ore, previously roasted in a reverberatory furnace, was submitted to lixiviation with the aid of a solution of ferric chloride or sulphate. When the ore contained more zinc than lead the chloride was used, but if the lead constituted the dominant element the sulphate was employed. Under these conditions the zinc is dissolved, yielding a neutral solution, while the ferric oxide is precipitated. The solution, thus free from iron, was submitted to electrolysis in vats arranged with batteries in sets of three; the cathodes were of zinc, copper or brass. In two of the vats the anodes were soluble and of iron; while in the third they were of charcoal. The vats were connected together by porous partitions of asbestos or of parchment, not reaching to the bottoms, so as to allow a constant circulation of the liquid. A third of the zinc contained is freed in the compartment of the cathodes by the solution, which, in contact with the anodes of iron, produces ferric bisulphite. This last salt, in contact with the carbon anodes, is converted into sulphate, which enters anew into action for the lixiviation of new quantities of the ore.

The Ashcroft process was completely abandoned in 1898 by the company which had purchased it, and this was the cause of great disappointment on the part of manufacturers and capitalists, who had founded magnificent hopes on this method, to judge from the claim made at the time of the first experiment. It is easy to see what are the causes of the want of success, and Ashcroft himself has recognized them. They are: (1) The impracticable employment of porous diaphragms, frequently breaking, fouling rapidly, and also opposing great resistance; (2) the precipitation and accumulation of the ferric oxide and the manganese, necessitating frequent stoppage and cleanage; (3) the system of incomplete circulation, the liquid being able to pass only from the bottom. The only advantage of the process to be considered resides in the slight quantity of electromotive force, which in the first vat was only 0.5 volt, and 1.5 in the third.

The Siemens method, applied to the refractory ores

of Brooken Hill, although having some similarity with Ashcroft's, is superior. The ore, ground and roasted, is lixiviated with dilute sulphuric acid or with an acid solution of zinc sulphate. The concentrated solution thus obtained is submitted to electrolysis, in wooden vats, with anodes of lead and cathodes of zinc, separated by porous partitions, not reaching to the bottom, and receiving air under pressure, which addition of air is designed to keep the liquid in circulation. As soon as this contains more than 10 per cent of free acid it is set at work for the lixiviation of the ores; the deposit thus obtained is regular and compact, but still the results obtained have not been satisfactory; for, at the factory of Lake Illawara, New South Wales, which had installed this process, it has been replaced by a process purely chemical.

The Dieffenbach process, introduced in 1895 in the factories of Duisburg for the treatment of ores of Siegen (Westphalia), appears to have given good results (in 1896 the production of these factories had risen to 90 tons per month), but it is quite probable that the expenses were found higher than in the usual metallurgic processes, for several German establishments abandoned this method last year. It consists in treating the roasted pyrites with a solution of zinc chloride, and then afterward submitting it to electrolysis in vats of special construction, of which a precise description has not been afforded, the process having been held secret.

Certain electrolytic processes are still worked, especially in Germany and Austria.

That of Nahnsen, established at the factory of Lepine in Silesia, consists in employing as an electrolyte a solution of the double sulphate of magnesia and sodium, which is almost the only information procurable on the course of procedure at this factory.

The Hoepfner process, which is worked on quite a large scale in Austria, Germany and England, is one of those which appear to have the most value. The electrolyte is a solution of zinc chloride containing chloride of lead or of sodium. The electrolytic vats are separated by diaphragms of special construction, kept secret. The anodes are of lead or of carbon; the cathodes are of zinc, of round form and actuated by a rotary movement. Their special arrangement is designed, according to Hoepfner, to remedy all the inconveniences hitherto met in the preparation of zinc by electrolysis. The operation takes place cold. The metal produced contains 99.70 per cent of pure zinc.

The method of Fry, in operation near Manchester, consists in dissolving zinc oxide in melted zinc chloride and submitting this mixture to igneous electrolysis. That of Hernek is installed near St. Petersburg and furnishes about 700 tons per year; but we have no precise data. Finally, there are the processes of Stepanow and of Swinburne.

Stepanow employs large rectangular vats, in which he arranges vertically anodes of lead or other conducting substances covered with leaves of silver and cathodes of aluminium.

Swinburne's process is by the dry method, in which the ore, melted with the aid of different fluxes, is electrolyzed; it allows of the methodical separation of the silver, the lead and the zinc. Judging from the first reports the results are excellent.

In conclusion, a very interesting process, patented quite recently by Ronbschensky, should be mentioned. By employing anodes of lead, and adding a little chlorate to the electrolyte, peroxide of lead is obtained at the anode, and zinc of superior quality at the cathode. If the chlorate is replaced with the chromate there is still zinc at the cathode, while at the anode chromate of lead is formed, which, considering its numerous uses in painting, can be sold profitably as a sub-product.

As a whole, the electro-chemical production of zinc, while having made remarkable progress during the period of its existence, has not yet really entered into the domain of industry. The principal obstacle is, in the opinion of electro-metallurgists, the cost price, which is too high for the metal obtained. Its success is intimately connected with the recuperation of the sub-product, which in the two most advanced processes (Hoepfner and Dieffenbach) is chlorine.

It cannot be doubted that the question will soon be solved, and that the manufacture of zinc by electrolysis will attain a development similar to that which has been secured in the electro-chemical treatment of copper ore.—Translated for the SCIENTIFIC AMERICAN SUPPLEMENT from the Revue de Chimie Industrielle.

England has decided to employ chiropodists in the army. They are to rank not above sergeants, and to perform the duties of enlisted men, but will receive extra pay of sixpence a day for six days in the week for cutting corr

LIQUID FUEL FOR STEAMSHIPS.*

BY EDWIN L. ORDE, of Newcastle-upon-Tyne.

THE subject of this paper is one which has already received so much attention that it is difficult to-day to contribute anything which possesses much value. A close examination of the literature which has appeared on the subject, however, seems to show that, from some cause or another, the many undoubted advantages which liquid fuel offers have either not been fully appreciated, or, if appreciated, not pursued with sufficient determination to insure that they shall be realized in actual practice. The explanation of this would appear to be that until comparatively lately liquid fuel was not obtainable in such quantities as are required to make it commercially useful.

For many years the Caspian Sea was the only place where liquid fuel was used in the furnaces of marine boilers, and, as the quantity available was not sufficient to allow of its export, it could only obtain a very limited application. Of late years, however, the sources of supply have largely increased in number, and now that the large oilfields of Borneo and Texas are in active operation, and commercial enterprise only needs the stimulus of demand to organize distributing stations, the question of the adoption of liquid fuel on a large scale appears to need for its solution only the close attention of engineers. The principal sources of supply are the fields of Borneo, Burmah, the Caucasus, Texas, and California; but there appear to be indications that further supplies exist, and, were the demand assured, would be explored and developed.

The subject seems to fall naturally into four divisions:

1. The characteristics and calorific value of the various forms of liquid fuel at present available.
2. The general conditions which govern its combustion in boiler furnaces.
3. The various types of apparatus which have been designed for utilizing liquid fuel.
4. The actual results which have been obtained.

Characteristics.—The composition of petroleum is in itself a study which demands special knowledge, and only the features which are of importance from the point of view of combustion need be considered in this paper.

---

*Paper read before the Institution of Mechanical Engineers.

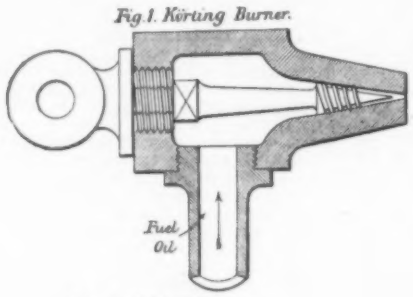


Fig. 1. Körting Burner.

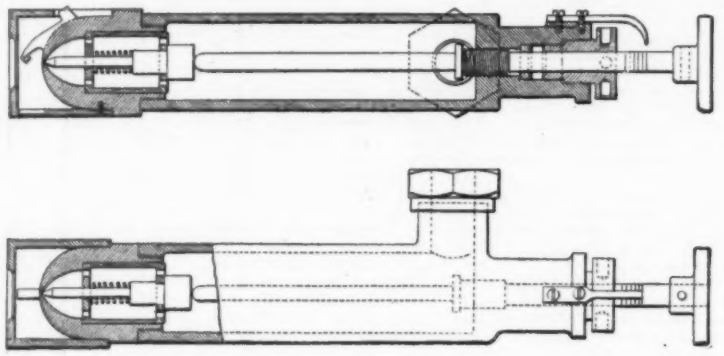


Fig. 2. Swenson Burner.

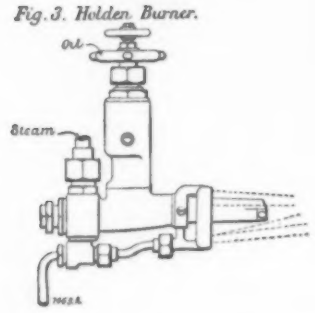


Fig. 3. Holden Burner.

Enlarged Views of Tongue Sprayer.

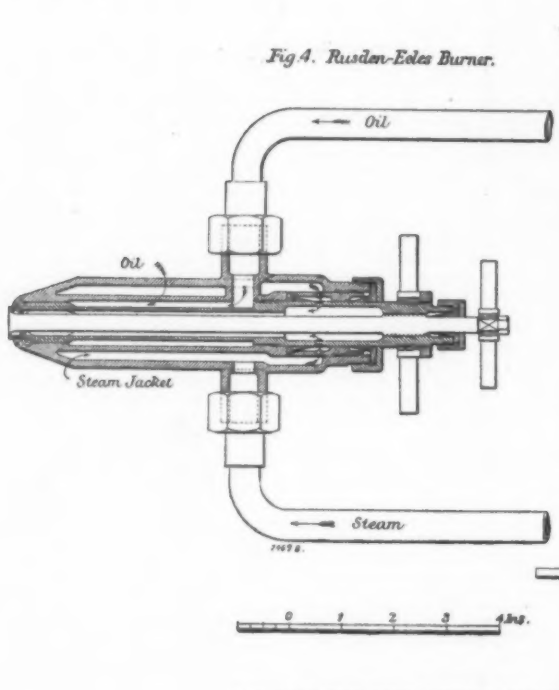


Fig. 4. Rusden-Edes Burner.

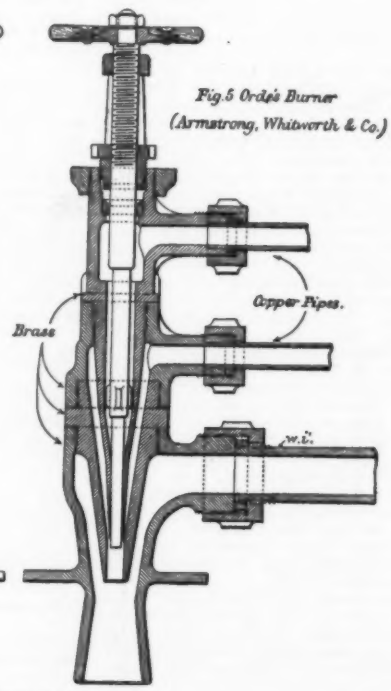


Fig. 5 Orde's Burner (Armstrong, Whitworth & Co.)

APPARATUS FOR USING LIQUID FUEL ON STEAMSHIPS.

The composition of petroleum is exceedingly complex, but as some of the phenomena which present themselves in using it as fuel are purely chemical, some attention to its principal characteristics is essential to the proper consideration of the subject.

Petroleum consists of a number of hydrocarbons, which occur in the following series:

1.	$C_n H (2n + 2)$	Methane.
2.	$C_n H 2n$	Olefine.
3.	$C_n H (2n - 2)$	
4.	$C_n H (2n - 4)$	
5.	$C_n H (2n - 6)$	Benzine.
6.	$C_n H (2n - 8)$	
7.	$C_n H (2n - 10)$	
8.	$C_n H (2n - 12)$	

Of the eight series, the first, second, and fifth are those which occur most frequently and in the largest proportions, and as of these three the first or methane series is probably the most important, a short consideration of its characteristics will be sufficient for the purpose of this paper.

The first four members of the series are gaseous (methane, ethane, propane, and butane), when in contact with air at ordinary temperature. The liquid members begin with $n = 5$ and end with $n = 25$; with higher values of n the members are semi-solid (paraffins). The boiling-point rises fairly regularly with the increasing values of n from $n = 9$ upward (each additional carbon atom representing a rise of about 20 deg. Cent.), as also does the specific gravity, although the increase is not so regular.

The crude petroleums as they come from the wells are usually refined by a process of distillation, and the products of the process may be roughly divided into three groups:

1. Light oils, distilling over up to 150 deg. Cent.
2. Illuminating oils, distilling over up to 300 deg. Cent.
3. Residuum.

The American light oils consist principally of the members C_7H_{16} to C_9H_{18}, and the illuminating oils C_7H_{16} to $C_{16}H_{34}$ of the methane series. The residuum can be subjected to higher temperatures when it yields (*a*) heavy oils which produce lubricating oils and paraffins and (*b*) carbon in the form of coke.

The members of the three groups are further subdivided into about 20 for trade purposes. The specific gravities of the three groups are approximately:

Light oils	0.65 — 0.78
Illuminating oils	0.78 — 0.86
Lubricating oils	0.86 — 0.96

No further consideration of the refining of the crude oils would be necessary were it not for two very distinct processes of distillation, both of which present phenomena which exert an important effect on the behavior of liquid fuel when treated in the burning apparatus.

These are:

1. The "cracking" process.
2. The effect of steam on distillation.

The "cracking" process consists in distilling over the lighter oils at temperatures above those at which they would boil under normal conditions. This is effected either by allowing the products of the distillation to condense and fall back into the contents of the still, or by distilling under pressure. The effect of the process is to decompose the heavier oils remaining in the still and materially decrease their specific gravity. The oil resulting from this process becomes more homogeneous in its composition than before; but if the temperature in the still reaches too high a point, solid carbon is deposited in the form of coke. These deposits of solid carbon, unless careful attention is paid both to the temperature to which the still is exposed and to its design, form a large proportion of the residuum after the lighter oils have been taken off; and continuous distillation on the "cracking" principle seems to be impossible owing to the rapid increase in quantity; but in the presence of steam, on the contrary, it appears to be possible to distill practically the whole of the crude product. One explanation of this phenomenon that has been given is that steam has the property of lowering the boiling points of the hydro-carbons with which it is brought in contact, and therefore allows them to volatilize at temperatures below those at which the cracking process sets in. Superheated steam is generally used in order to attain the temperature required for distillation, which reaches 550 to 600 deg. Fahr. in many cases. Air does not possess this solvent property, nor is it so convenient a vehicle for the heat required in the process of distillation. This part of the subject has been dealt with at some length, as the process of presenting the liquid fuel in boiler furnaces in the most suitable conditions for combustion is in many respects an analogous one. Before complete combustion can take place, the fuel must pass from the liquid to the vapor form, and it is obvious that the most successful apparatus must be that which accomplishes this object with the smallest expenditure of heat. The fuel oils in general use are the crude oils of Borneo and Texas, and the residual oils of the Caucasus and Burmah. The ultimate analysis of these oils is given in Appendix A.

It has been suggested by some of the early writers on the subject that liquid fuel has a higher calorific value than solid fuel of the same chemical composition, from the fact that a certain amount of heat has been rendered latent in passing it from the solid to the liquid form, and it has therefore been argued that heat values calculated on the basis of solid carbon are under-estimated to the extent of this latent heat of liquefaction. Dr. Paul, who investigated the subject very closely, has suggested 6,000 British thermal units as the value of the heat thus lost; but as this is the value assigned by Rankine to the latent heat of the gasification of solid carbon, it would appear to be too high for the latent heat of its liquefaction. The determination of the heat value of petroleum by the bomb calorimeter does not show the existence of this latent heat, and Dr. Paul comes to the conclusion that it is not probable that petroleum, when used as fuel, can be made to evaporate more than about 16 pounds of water from and at 212 deg. Fahr. This agrees with nearly all the well-authenticated results that are on record.

Taking Borneo oil as an example, some heat balance-sheets that have been experimentally obtained are given in Appendix B.

The heat lost in radiation was measured at a separate trial, the amounts thus found were interpolated in the balance-sheet, and found to agree very closely with the

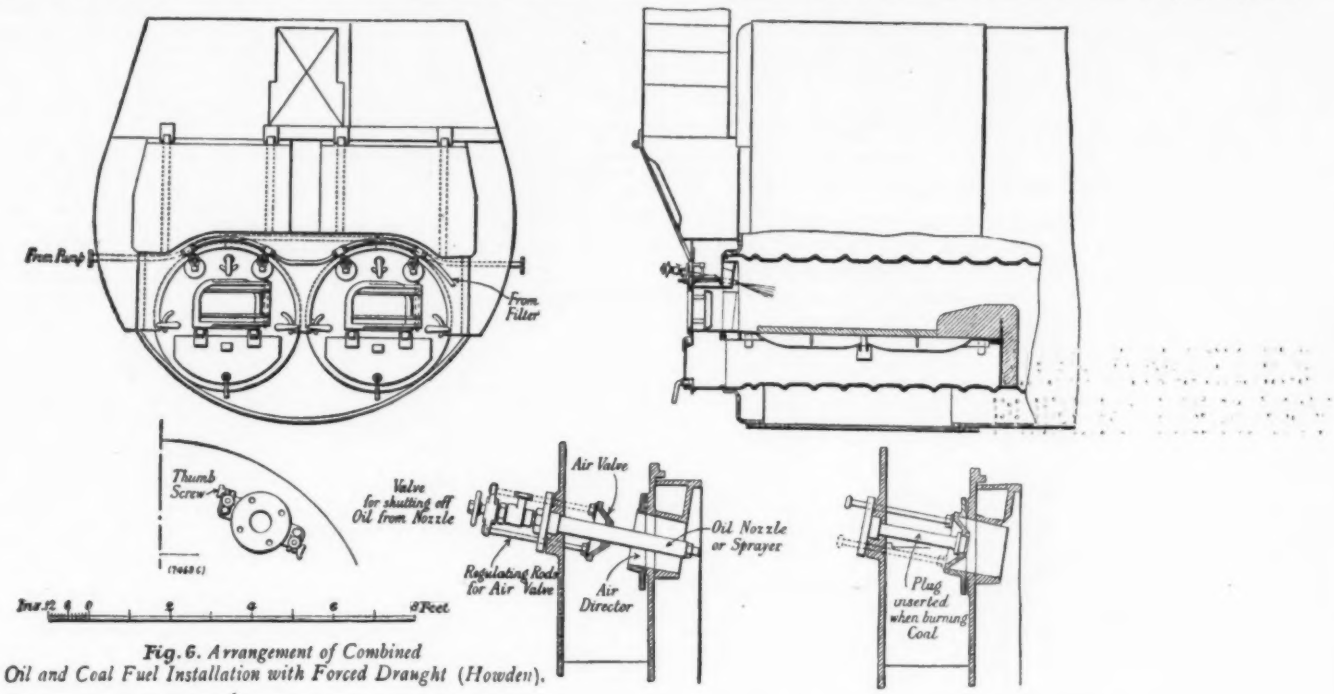


Fig. 6. Arrangement of Combined Oil and Coal Fuel Installation with Forced Draught (Howden).

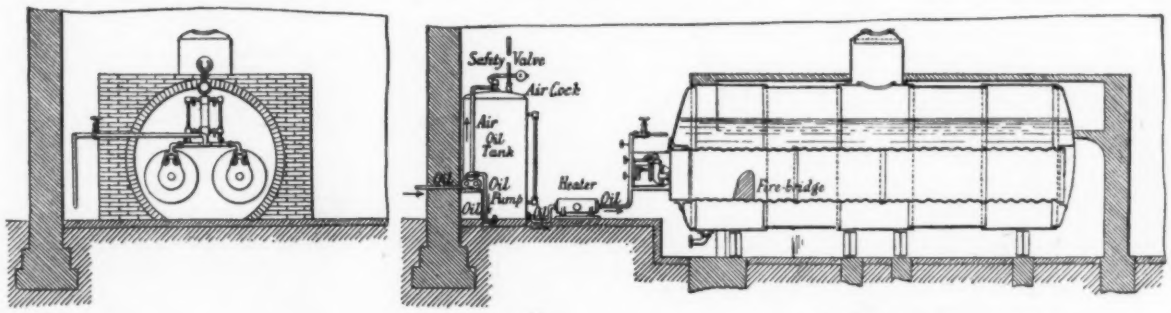
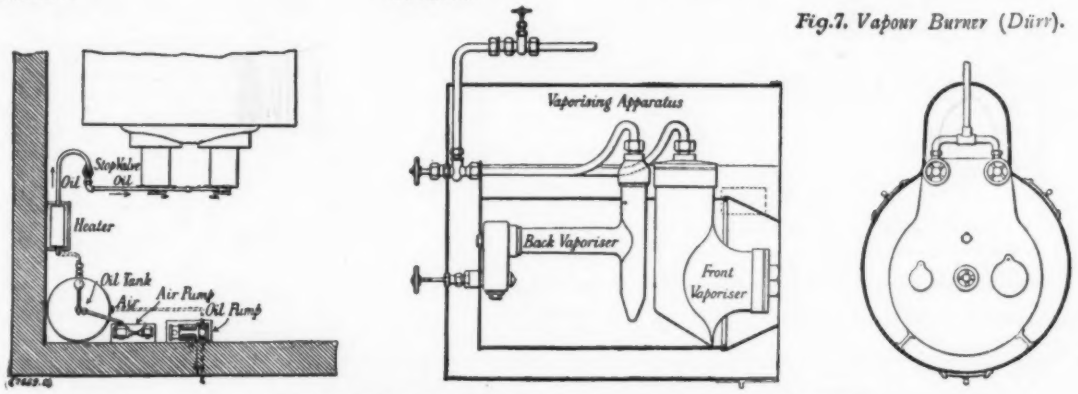


Fig. 7. Vapour Burner (Dürr).



APPARATUS FOR USING LIQUID FUEL ON STEAMSHIPS.

result found by difference in the usual way, in all cases but the second, when the observed evaporation was undoubtedly too high. The observed evaporation results were 15.4, 15.95, 14.6, and 14.48 respectively. The difference between the first and second pairs of experiments is due to the presence of water in the oil. This exercises a very important function in the behavior of the fuel, and is responsible for much of the difficulty that has attended its use. The actual reduction of the heat value of the fuel = 13.14 British thermal units per 1 per cent. water, in addition to the loss of the oil which it replaces: for example, 1 pound of oil mixed with 10 per cent. water evolves

$$18831 \times 0.9 = 16947.9 \text{ British thermal units}$$

$$\text{less} \quad 131.4 \quad " \quad "$$

$$= 16816.5$$

a difference of 1915.5 British thermal units, or a loss in evaporative power of nearly 2 pounds of water from and at 212 deg.

Besides this actual loss of heat, the presence of water destroys the conditions necessary for perfect combustion, and this occurs and may cause considerable damage to boilers of the ordinary marine type, although the quantity is not sufficient to extinguish the flame. The first effect is naturally to reduce the temperature of the flames and thereby increase their length, thus moving the point of highest temperature further into the furnace, which has the effect:

1. Of rendering a large portion of the furnace heating surface entirely useless.

2. Of raising the temperature in the combustion chamber to a point which may be hurtful to the material.

3. Of causing the last stage of combustion to take place in the smokebox and funnel.

The conditions that attend and the reactions that take place in burning liquid fuel in boiler furnaces present a problem which has apparently not received the attention which it deserves. Petroleum vapor depends entirely on temperature, and it is therefore almost impossible to collect samples when actually burning it in a furnace. It seems obvious that the first effect of the furnace heat on the petroleum spray is to liberate hydrocarbon vapors, and to ignite them on the outer surface of the jet. The ignition raises the temperature of the whole of the jet, and probably dissociates some at least of the hydrocarbon vapors into carbon monoxide and hydrogen. In what form the undissociated hydrocarbon vapors burn it is difficult to conjecture, but the appearance of the flames suggests that acetylene is present. This might conceivably arise from the reaction $CH_4 + CO = H_2O + C_2H_2$. As the temperature of the flame rises, the hydrocarbons are probably all dissociated and burn as CO and H to CO_2 and H_2O without further change. When the conditions are satisfactory, the flames are opaque and dazzling white in color for a distance of some 6 inches from the nozzle of the burner, become semi-transparent, and almost violet in color at the middle of their length, and shade into red at the end. In burning oil which is mixed with water the combustion is incomplete, the violet color never appears, and the end of the flame is dark red and fringed with smoke. In some cases, where water is present in comparatively small quantities, the end of the flame is white and presents the appearance of acetylene, which may arise from want of sufficient heat in the flame to decompose the hydrocarbons. This has been observed, when, although no smoke was formed, and the air supply was not more than 20 per cent. above what is chemically necessary for the fuel, the evaporation performance of the boiler was poor, which confirms the existence of a low furnace temperature.

The "burners," which have been designed for admitting liquid fuel into boiler furnaces, numerous as they are, may be broadly divided into three distinct types. These are:

1. Mechanical spray, in which the liquid fuel is forced under pressure through nozzles, made of such a form as to break it up into a fine spray and thus render it inflammable.

2. Spray burners, where the liquid fuel is held in suspension and driven into the furnace by means of a jet of steam and compressed air.

3. Vapor burners, in which the liquid fuel is volatilized and the vapor admitted to the furnace.

So many of these burners have been designed by various inventors that it is impossible to describe more than one or two, which are typical of each of these three main divisions, without overstepping the limits of a paper, and in making his selection the author has endeavored, as far as possible, to treat of those that have stood the test of actual working at sea.

Of mechanical spray burners very few have achieved success. It is obviously very difficult to devise an apparatus which is capable of dividing into a fine spray a material so thick and viscous as fuel oil. The best known and most successful burners of this type are those of Messrs. Körting Brothers (Fig. 1). The oil is first heated to a temperature of 130 deg. Cent. and then forced under a pressure of about 50 pounds per square inch through nozzles, each of which has a small orifice at the apex controlled by a central spindle with an enlargement of spiral form, so arranged as to impart a vortex motion to the oil as it passes through, of sufficient intensity to make it fly into spray by centrifugal force as soon as it issues from the nozzle.

Fig. 6 shows the way in which these burners are generally arranged, and the refractory lining to the furnace. Some such arrangement is necessary to maintain the temperature at a sufficiently high point to vaporize the fuel, and to prevent condensation of the flame before it has attained the temperature required to insure complete combustion. Another burner of this type is that of Mr. Swensson, of St. Petersburg (Fig. 2). Here the fuel passes through a minute orifice, and is divided into spray by striking against a cutter placed at a short distance from the orifice. An adaptation of the Körting burner is used by Messrs. Howden, who have supplied some installations to boilers fitted with heir well-known system of forced draught (Fig. 6).

The second type is by far the best known. Typical examples are: The Holden burner (Fig. 3), and the Rusden-Eeles burner (Fig. 4). Both these burners are designed to work with steam as the spraying medium but in the Holden burner a current of air is induced by means of a ring of steam jets outside the flame which insures a rapid ignition of the outer layer of the spray, and a central current of air is also induced by the action of the jet of steam and oil passing from the burner.

The Rusden-Eeles burner (Fig. 4) is so well known as not to require a detailed description; it allows of separate adjustment to the steam and oil jets, and is in all respects a simple and workmanlike fitting.

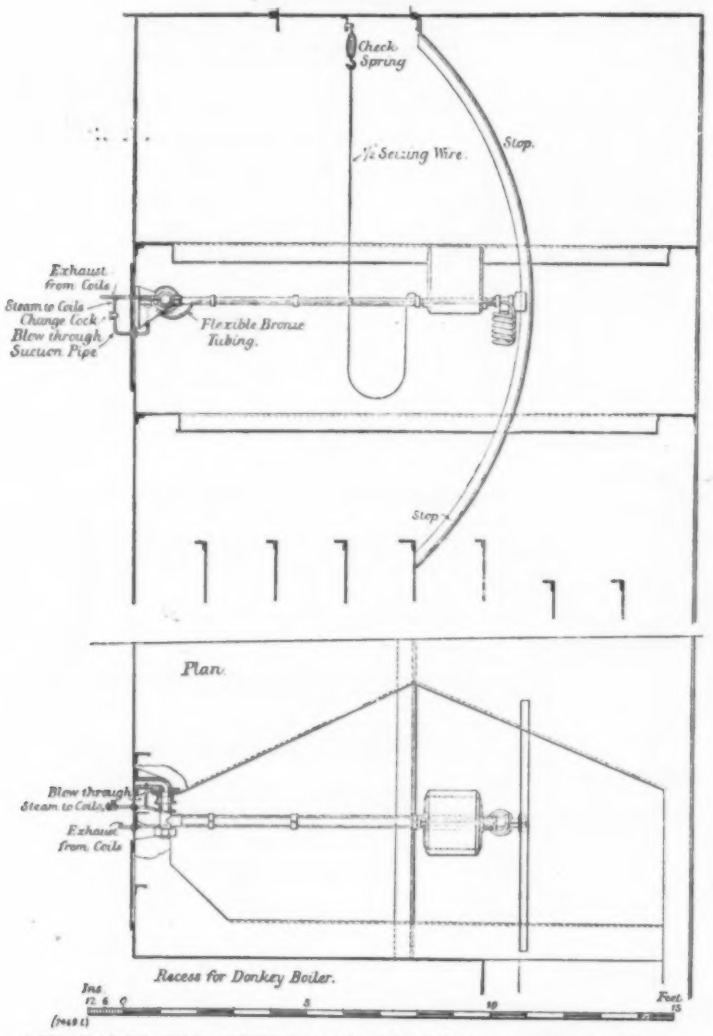
Fig. 5 shows a burner designed by the author to vaporize as much as possible of the fuel to prevent any possibility of cracking the oil, and at the same time to sweep out in the form of spray any of the heavier products which might remain undistilled. The burner is designed to work with highly superheated steam (preferably 600 deg. Fahr.). The velocity of the jet induces a current of heated air, which insures instant ignition of the outer layers of the flame and consequent increase of temperature over the whole of the jet.

Of vapor burners pure and simple the author only knows of one at the present time—the Dürr (Fig. 7). Here there are two reservoirs for containing oil, etc., called by the inventor "gasifiers" (Vergäser). The smaller gasifier is heated by means of a fire, and as soon as the oil which it contains is sufficiently heated to give off vapor, the vapor is lighted, and the flame serves to heat the large gasifier, the vapor from which is burnt in the furnace of the boiler to which it is fitted. As soon as this flame is well established, the temperature inside the outer casing covering the two gasifiers is sufficient to maintain the vaporizing process.

In addition to the actual burning apparatus, no installation can be considered complete without (*a*) some form of filter to cleanse the fuel oil of impurities, and (*b*) some arrangement for separating water. This last is by no means so simple as it would at first sight appear. The specific gravity of most fuel oils is about 0.92 to 0.96, so that separation by the action of gravity alone is an exceedingly lengthy process, and practically never complete; but as the coefficient of expansion of fuel oil is considerably higher than that of water, the action may be greatly hastened by heating the contents of the tank; the combination of oil and water, however, is curiously intimate, and a careful experiment showed that at a temperature of 140 deg. Fahr. seven days elapsed before the water was completely separated. A large expenditure of heat is required if the contents of the fuel tanks are to be maintained at such a temperature, and it is obvious that, unless the separating process is complete and the water is all drained out of the tank before any of the fuel is drawn off for use in the burners, the lower layers, which are the first to flow, are formed of a concentrated intermixture of oil and water. One way out of this difficulty consists of a swing pipe supported at one end by a floating vessel. The orifice of the pipe is arranged at a suitable distance below the surface of the liquid fuel, and a coil of steam pipe is fitted so as to raise the temperature of the oil immediately surrounding the opening into the pipe; the fuel passes through the swing pipe on its way to the burners, and is to a great extent freed of water at a comparatively small heat expenditure (Fig. 8).

It is impossible within the limits of a paper to describe fully the various arrangements that have been designed for burning liquid fuel, and the author would refer those who wish to pursue the subject to the writings of M. Bertin. The actual results obtained by successful installations of burning apparatus on sea-going steamers are somewhat difficult to obtain, but owing to the courtesy of the Shell Transport and Trading Company, the Burmah Oil Company, and Messrs. Körting, the author has been enabled to give figures showing the actual consumption of liquid fuel in practice as exemplified by mechanical and steam spray burners. It is obviously impossible to draw any exact comparison between solid and liquid fuels without complete trials carried out in such a way as to show the actual boiler performance, and there are, unfortunately, no available data which allow of this being done properly from a scientific point of view. Commercially, however, the results have some value, and to make the comparison as useful as possible, the corresponding consumption of coal as actually ascertained is given in four cases.

Fig. 6. Water Separator.



APPARATUS FOR BURNING LIQUID FUEL ON STEAMSHIPS.

Name of Ship.	Type—Burning Installation.	Consumption per Indicated Horse Power per Hour in Pounds.	Corresponding Consumption of Coal.	Heating Surface.	Indicated Horse Power.
C. F. Laiesz.	Körting.	1.408	1.93	7,560	2,200
Sithonia.	Howden.	1.065	1.49	....	2,500
Murex.	Rusden-Eeles.	1.3 ? 16 tons*	25 tons.	5,202	...
Syriam.	" "	1.32	....	2,480	800
Khodoung.	The Author. Armstrong, Whitworth & Co.	1.08	1.67	2,700	980

* The consumption in this case is given in tons per day. From Sir Fortescue Flannery's paper in the Transactions of the Institution of Naval Architects, 1902. No indicated horse power was given.

Differences in consumption in favor of liquid fuel as compared with coal:

	Per cent.
"C. F. Laiesz"	say 27
"Sithonia"	" 28.6
"Murex"	" 36
"Khodoung"	" 35.5

All the vessels have triple expansion engines of normal proportions, except the "Sithonia," in which quadruple expansion machinery is fitted, and from the coal consumption trial the amount of water required per indicated horse-power must be considerably less than in the other vessels referred to.

From the figures given above, it is evident that with a well-designed apparatus it is possible by good management to realize in actual practice the full difference in calorific value between liquid and solid fuel, at rates of evaporation such as are usually obtained in the boilers of vessels of the mercantile marine. At the higher rates

of evaporation, such as required in war vessels, the problem becomes more complex; but now that it is receiving the serious consideration of the Admiralty, there can be no doubt that a satisfactory solution of this most important question will be arrived at.

In presenting this paper the author, while conscious of its many shortcomings, hopes that it may serve to initiate a discussion in which more light may be thrown on the delicate problems involved in the combustion of liquid fuel than has hitherto appeared.

APPENDIX A.—FUEL OILS.

	Carbon.	Hydrogen.	Oxygen, etc.
	Per cent.	Per cent.	Per cent.
Borneo	87.8	10.78	1.24
Texas	85.66	11.03	3.31
Caucasus	84.94	13.06	1.25
Burmah	86.4	12.1	1.5

The calorific values are:

	B.T.U.
Borneo	18,831
Texas	19,242
Caucasus	18,611
Burmah	18,864

These values are determined by the calorimeter.

APPENDIX B.—HEAT BALANCE-SHEET OF BORNEO OIL.

Loss Due to Moisture.	Units of Evaporation.			
1. $\frac{10.78}{100} \times 9 \times (212-t) + 966 + 0.48\ (T-212)$ (where t = initial temperature of oil; T = temperature of escaping gases).	1.15	1.0	1.2	1.19
2. Losses due to heat carried off in escaping gases. $\frac{1 + A^1 \times T}{4000}$ (A = weight of air required for combustion — observed)	1.46	1.6	2.3	2.21
3. Loss due to radiation (observed)	1.3	1.4	1.3	1.38
4. Heat employed in evaporation.	15.4	15.4	14.5	14.6
Total heat value of oil	19.4	19.4	19.4	19.4

THE CHEMICAL FACTOR IN HUMAN PROGRESS.*

By PETER T. AUSTEN, Ph.D., F. C. S., late Professor of Chemistry in Rutgers College and the Brooklyn Polytechnic Institute.

WHAT is now called chemistry is not an old science. It is true that the name chemistry is supposed to be derived from Chemia, the ancient name of Egypt. The Arabians, who in the year 640 A. D. overran Egypt, obtained their knowledge of chemistry, that is, the crude rudiments then known, in that country, and prefixed the Arabic article to the word, thus producing the term, Alchemy. The word Chemia first occurs in the Byzantine writers of the fourth century and refers to the art of making gold and silver, and also means the Secret, or Black Art.

In the writings of Geber, who was the most distinguished of the Arabian alchemists, many chemical operations, such as filtration, distillation, crystallization and sublimation were known, and by their use he produces new substances and purifies known ones. A number of substances are described, as alum, green vitriol, saltpetre, sal-ammoniac, aqua fortis and aqua regia, the solvent for gold, and also oxide of mercury and corrosive sublimate; perhaps, too, sulphuric acid. Still it was alchemy, not chemistry. In the thirteenth century the knowledge of alchemy had spread from the academies of Spain all over western Europe. In Spain was Raymund Lully; in Germany, Albertus Magnus; in France, Arnold Villanovus; in England, Roger Bacon, who was tried for sorcery, and who showed that certain appearances attributed to supernatural agency were due to natural causes. In the fourteenth century interest in the study had still more increased and many new substances had been discovered. The old idea of Geber that all matter was composed of sulphur and mercury was generally accepted, and now Basil Valentine adds a third constituent, salt. These were supposed to be principles, and hence not necessarily identical with the substances bearing their names. The Aristotelian symbolic elements, earth, air, fire and water, had been given up. Up to about this point chemistry had meant an attempt to make gold and silver. Now the era of medical chemistry began, and the search after the *elixir vitæ*, a cure for all ills, began; and in this search many valuable medicines were discovered. Chemistry was the servant of medicine. I might trace out more fully the development of the science, but I simply wish to point out how young a science chemistry is. We are now in the sixteenth century and not yet is there an idea of a science of chemistry. From about this period up to 1770 discussions and wordy wars were waged, wild theories and speculations were advanced and refuted, but no means were at hand to enable the investigators to apply exact measurements to the chemical changes of matter. In 1770 the great French investigator, Lavoisier, announced the principle of the indestructibility of matter, proving it by the use of the balance, and chemistry became an exact science.

It is hard to appreciate the enormous advance that science had made in the last century. Think of the marvelous wealth of chemical knowledge at our disposal to-day, and then recall the fact that only 131 years ago chemistry became an exact science. It was seen then that a chemical change involved the weight of the materials used. Discovery followed discovery, and in 1803 John Dalton gave to the world, in intelligible language, the first real chemical law, the law of chemical combination in definite and constant proportions, and the first real chemical theory, the atomic theory. More exactly, Dalton propounded the first quantitative atomic theory, his predecessors having suggested only qualitative ideas. Now followed Guy Lussac's law of combination by gaseous volume, the wonderful law of Avogadro, the foundation of our modern chemistry, the law of specific heats of Dulong and Petit, and the law of isomorphism by Mitscherlich. I will stop here. The precious metal had been found. Many had been the prospectors in this mine of wealth. Here and there a nugget had been found, but now the great vein was opened and energetic, hardy workers bent to the toil. Discovery followed discovery, ramification on ramification of noble metal was disclosed. The world seemed flooded by the continually increasing additions to its wealth of knowledge. And there has been no abatement in the yield of this wonderful source. Let us examine some of these discoveries, their applications to human affairs, and their influence on the development of mankind.

It is not easy to fix exactly the dates or beginnings of discoveries. Almost every great advance* bears the imprint of many hands, and it is not always easy to say just at what point it began. If Darwin and Spencer did much for the theory of evolution, it must not be forgotten that Kant, Goethe, Lessing, Herder, St. Hilaire and Lamarck also pondered over it, and that seven centuries before Christ it was agitated. Several critics in attempting to rob Darwin of his share of this work by citing previous workers in the field, have quite unconsciously strengthened the theory by showing that it, like many others, has grown by slow development. So with the atomic theory. The seeds sown amid the speculations of Lucretius about atoms, which for hundreds of years had been shuttlecocks for metaphysicians, germinating in more favorable soil, bore a flower of most wondrous beauty, the atomic theory of John Dalton.

One of the most difficult things to actually realize is the fact that, but a short time ago, almost all of what we now term necessities of life did not exist. Railroads, steamships, telegraphs, and all the mechanism of our life to-day were then unknown. "In the thirteenth century," writes Gore, "we knew nothing of foreign wines, foods or fruits, watches, clocks, steel pens, bank notes, checks, money orders, the postal system, police, telegraphs, paved streets, macadamized roads, stage coaches, cabs, omnibuses, tramways, railways, canals, steam engines, steamships, gas lighting, electric lighting, photography, bicycles, sewing machines, pianos, silk, alpaca, wool, soap, coal-tar dyes, artificial manures, phosphorus matches, petroleum lamps, articles of gutta percha, and india rubber, etc., and many other conveniences."† Even we have seen the telephone take up its place among our valuable but not always obedient servants. And many of us will probably live to see thermo-electricity grow to be a giant who shall place at our disposal powers as yet almost incalculable.

Running over some of the great chemical developments to find a starting point, agriculture appears to be a good field to begin in. As agriculture is the oldest industry on the face of the earth, it is not strange that many facts should have been discovered during the centuries of its practice. But, before chemistry was developed, there could be no science of agriculture. What was known was purely empirical, and no reason could be assigned for the result. Many may be surprised to know that scientific agriculture dates from 1862, thirty-nine years ago, the date of the publication of Liebig's great work on "The Chemical Process of Vegetable Nutrition and the Laws of Agriculture." Liebig's first work appeared in 1840, and was met with a storm of abuse and criticism. But then the world usually treats a new idea in that way. Abuse by the world often means that one has evolved an idea having some claim to originality. It seemed particularly to vex the public that a chemist should meddle with agriculture, and dare to assail the views of practical farmers. The book went through many editions and then dropped out of notice, for, although founded on correct principles, Liebig had erred in his inferences, and his ideas when put into practice failed entirely. Liebig stated that the plant lived on, or assimilated, the simple or inorganic constituents of the soil and converted them into complicated organic substances such as cellulose, sugar, albumen, etc., and that the animals lived on the plant; that the plant built up complicated substances out of simple ones, and that the animal consumed these complex substances and then converted them back into simple substances. In other words, the plant was a synthetic organism, and the animal an analytic. To establish this, and to found upon it a practical method of agriculture and physiology, was a work so colossal that it is no wonder that even the mighty intellect of Liebig should have failed at first to grasp all of the details. Liebig examined an immense number of plants from all parts of the world, and found that while the plants all contained the same ash-constituents, different kinds contained different proportions of these mineral ingredients; even different parts of the same plant, as the leaves, the stalks or the seeds, contained varying relations of ash-constituents. As a result, Liebig was able to state that every plant takes from the soil a certain amount of mineral substances as a definite mixture, and that these substances will be found again in the ash, and that the carbonic acid and ammonia which the plant requires to form its combustible parts are taken up through its leaves and roots from the atmosphere. If wheat, or corn, is grown on a field, year after year, in time the mineral food of the soil will become exhausted and the plants will not thrive, but will be dwarfed and puny and incapable of enduring the weather, or will die of starvation. Now, if the proper amount of mineral nutriment be added to the soil, the plants will grow, and the atmosphere and mechanical nature of the soil will look after the rest.

A factory was established to manufacture artificial fertilizers according to Liebig's idea, but after several years of trial it was found that they were a complete failure. Liebig knew that his theory was right, but was unable to explain why it failed in practice. He worked and thought, and thought and worked. After several years he noticed that certain fields which he had treated with his fertilizers, and which had not been bettered by them, began to show slight but marked and increasing signs of fertility. In the meantime, the English farmer, Lawes, working with a chemist named Gilbert, showed that fertilizers would produce effects if added in a soluble form, and further that ammonia and forms of nitrogen were not taken up by the plants from the air alone, but that they must be added to the soil. If these conditions were followed, the yield of a field was enormously increased. Liebig had supposed that if his fertilizers were easily soluble in water they would soak through the earth before the plant could assimilate them, and had hence made them as difficultly soluble in water as he could. But Thompson and Way long ago proved that surface soil had the power to retain certain substances when in solution. The scales fell from Liebig's eyes. The mineral food of the plant must be placed on the soil in soluble form; the soil would hold it and the roots would absorb it. In 1862 appeared the new edition of his great work, and agriculture became a science. The manufacture of artificial fertilizers became an industry. It was easy to find out what was the proper food of any plant, and no farm need suffer from exhaustion. Since then the progress in this branch of science has been so rapid that it is hard to follow it. The striking facts of this discovery have been merely touched upon; there are many minor ones, and the conditions necessary for the successful application of the results are numerous, but every day shows advance in our ability to understand and apply them.

What are the effects of this discovery upon civilization? We find that agriculture as a livelihood, indeed, as a profession, has enormously increased. The vast deposits of fossil bones, phosphate rock, and of guano have been opened, and have developed a great industry, as well as have increased the resources of the world many fold. Stations have been established in many places for the examination of fertilizers and the determination of their value by chemical analysis, and employ a small army of trained chemists. The education and protection of the farmer have become a matter of national importance. Instead of farming land until it is used up, or relying on an empirical rotation of crops, the nutrients taken from the soil are systematically put back. Careful study of the chemical composition of a plant and the effect of chemical fertilizers enable us to develop certain products formed by the plant. Thus the beet root, by careful treatment, has been compelled to produce a far greater amount of sugar than formerly, and Germany has been freed from her dependence on other countries for her supply of sugar. Certain substances have been found to increase the specific functions of a plant, and so a plant can be developed into leaves, roots, stalk or seed. Its stalk can be strengthened or weakened. In fact, we are getting to be more and more masters of the vegetable kingdom, or in other words, we can make two or even ten spears of grass grow where there was but one, and each will be bigger than the original one.

No man who has brains and muscle, and who is not afraid to work, need ever starve in this country, where land is so plentiful. Let us note one fact here, which is often overlooked. The great wave of agricultural development has swept over the West and is rolling toward the Pacific. These pioneers skim the cream. When the soil gets exhausted they move on to new ground. This is not an entirely beneficial production. We are sending, it is true, vast amounts of grain and foodstuffs to Europe, and money is coming back, but in what proportion? The mineral ingredients of these breadstuffs are lost to us, and soon we shall have to replace them, which will cost us more, perhaps, than we have received. In 1883 we exported:

Of wheat	$120,000,000
Of corn	28,700,000
In all	$148,700,000

The cost of production of this was $60,400,000, so that one might think that there was a profit of $88,300,000.

According to Prof. Voorhees, of the New Jersey Experiment Station, however, there were in this exported wheat and corn 70,000 tons of nitrogen, 40,000 tons of phosphoric acid, and 21,000 tons of potash, which are worth, at market rates $33,000,000. Hence our real profit is only $55,300,000, and a corresponding decrease in the capital stock of the West. This amount in time must be replaced, or our soil will become exhausted. So long as we can draw on our native supplies, well and good, but the time may come when we may have to buy them back, and at an advanced price.

In a word, then, Liebig's great discovery has done much to develop the prosperity and independence of nations, for the independence of a nation will be based largely on how well it can feed its inhabitants, that is, its power of endurance. No better result of the wonders that scientific agriculture can accomplish may be seen than in the States of Connecticut and New Jersey. Look at the thousands of acres reclaimed from stone and sterility and now yielding bountiful crops under scientific treatment. Nor forget what honor is due to the men who, by dint of sheer persistence, grit and brains, introduced Liebig's work into this country, and who have educated the plain agricultural workers to such an extent that these States can compete with others better adapted by nature for agricultural production, who established the first agricultural stations, after which all of our others have been modeled, and to whom not only these States but our whole country owes a debt of millions of dollars, if prosperity can be repaid in cash. I mean Prof. Samuel W. Johnson, of New Haven, and Prof. George H. Cook, of New Brunswick.

Let us now look into the subject of live stock and see what chemistry has done there. Lavoisier had shown that animal warmth was due to processes of oxidation, a kind of burning of the carbonaceous and hydrogenous substances in the body, just as the heat of burning wood is caused by the oxidation of the carbon, its chemical union with oxygen. Dulong and Despretz proved that nine-tenths of the heat produced in the body was owing to this cause. The heat of our bodies appears to be a kind of flameless fire. Bodily heat is very much like steam heat, and to produce it

* A lecture delivered before the Bridgeport (Conn.) Scientific Society.

* Listen to poor, dear, old Plato bewailing 2,000 years ago the degeneracy of modern music. Jowett, volume IV. Laws, page 229.

† Gore, "Some Relations of Science to Morality and Progress." Open Court, volume 1, page 459. See also address before British Association for Advancement of Science, by Sir Henry Roscoe, SCIENTIFIC AMERICAN SUPPLEMENT, volume 24, page 9788.

fuel must be constantly kept burning under what may be termed the boilers of our organisms.*

In the subject of animal nutrition the mighty mind of Liebig again found a vast field to till. In many ways this was no new and untrodden ground. Physiologists had accumulated hundreds of interesting facts, but the great question, how is it that although the nutrition of the various animals is so different, the composition of their bodies is so nearly the same, had not been answered. The flesh of the ox, the bird, and the man is about the same thing. The change of substance in a hungry herbivorous animal is about the same as in a carnivorous one. From the day of Hippocrates to 1840, this question had been becoming more clearly defined, but the answers to it were conflicting and unsatisfactory. Suddenly, like a flash of lightning, the darkness was dispelled. The essential facts had all been found, but a chemist was needed to translate and explain them. It was like the old story of the writing on the wall. It was there, but no one could read it. It would take me too far from my subject to attempt to explain the details of Liebig's views of physiological chemistry, to relate the fierce polemic wars waged on these questions; for the dictum of Ranke is as true in the history of science as in the history of nations: "All progress is through conflict." Suffice it to say that Liebig was the first to definitely assert that the animal must find the chief constituents of its blood, which form and nourish its whole body, ready formed in its food, and these substances originate and are found in the plants. Following this up, we find that the animal is a kind of chemical factory in which many chemical processes are carried out. The machinery belongs to physiology; the processes, however, are largely chemical.

Chemical statistics in relation to animal life were collated and increased. Animals were analyzed wholesale, and their chemical composition determined. For instance, Lawes and Gilbert found that the analysis of 348 whole sheep gave an average of 2.34 per cent of ash, 7.13 per cent of protein, 70.4 per cent of fat, and 20.1 per cent of water. All kinds of animals were examined, and the composition of entire specimens and of the various organs and fluids determined. Foods were examined chemically, and, in fact, not only the body of the animal, but all that went into it and came out of it was analyzed by the chemists. The result of all this was that chemists found the animal to be as susceptible of experiment as the plant. Live stock can now be fed, for instance, to make flesh, to make fat, to yield milk, to produce work, or to simply maintain life. The nutritive elements of food can be determined and their digestibility estimated. The economy of foods can be calculated, and, in fact, the whole subject of animal-raising has passed from empirical management to scientific organization, and in this field, too, the progress has been rapid, and is still wonderfully rapid.

The animal is now studied very much like a steam engine; in the one case we feed coal and get steam, power or heat, in the other, we feed fodder and get milk, flesh, or power, as the case may be. A "ration" can now be made in which the digestible proteine, the fat and carbohydrates can be obtained from the most various sources, and the fluctuations of the markets taken advantage of to produce the raw materials. The nutritive value and digestibility are carefully adjusted, and, as a result, for instance, we are able to produce milk at a total expense of 2½ cents a quart. In this country the science of live stock feeding is as yet in its infancy. We are, at least in the West, gathering the bloom of the land. Our cheap beef† and our cheap corn can be produced only for a time. Sooner or later the riches taken from the soil must be put back again. It would be hard, indeed, to trace all the effects of these discoveries on the gradual progress of civilization. Cheaper food and more economical and profitable agriculture strengthen the great tap-root of all civilization and human relations on this earth.

As a result of all this great advance in our knowledge of scientific agriculture farming has become a profitable profession, and I predict that more and more we shall see educated young men entering it.‡

The chemical study of foods has been carried up to the feeding of men. Prof. Atwater, of Wesleyan College, has published the results of his investigation on the cost of supporting workmen, and finds that the amount of food necessary to support a man, and enable him to do his daily work, can be obtained at a cost of 12 cents a day. For 45 cents a man can live sumptuously. When meals are provided for a number at once the cost is ridiculously small. It might be well for some of the knights of labor and serfs of capital to look into these matters. What a frightful waste there must be in our household economy of to-day.

What a future looms up in this field of study. Think of the suffering and want that this accurate chemical work will alleviate when it is understood and appreciated. The German government supplies the people in certain districts with plainly written tracts explaining what are the most valuable nutriments in foods and about what amount of each is needed to make a daily ration which shall neither want nor

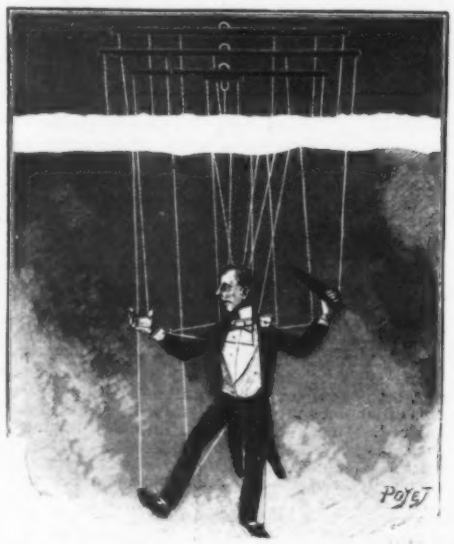


FIG. 2.—A PUPPET AND ITS THREADS.

waste valuable substance. Our own government is doing the same. Chemical knowledge gives an enormous increase in the purchasing power of a country, and greatly ameliorates the environment by making it more favorable to the people.

In the days of old, people supposed that every object was a particular kind of matter. It is true that Aristotle believed in four elements, earth, air, fire and water, but these were used largely in a figurative sense. Wood was a substance, so was coal, so was water, so was air. They were supposed to be different kinds of matter. As chemistry began to develop, during the last hundred years, it was found that all the different kinds of matter about us could be resolved into a certain number of simpler substances, and that these simple substances could not be further altered. They were hence called elements. So far about seventy-five of these elements have been found. All of the material objects about us are compounds of these elements; some, of course, being very common, and others more or less rare. Oxygen, for instance, a colorless gas, but when in combination, giving rise to compounds of the most various properties, constituting one-half of the earth's crust, nearly one-quarter of the air, and about one-half of clay, sand and limestone. At first, methods of ascertaining the percentage composition of substances were very crude, but during the last fifty years they have, by means of the exquisite delicacy of the chemical balance and our increased knowledge of the chemical behavior of substances, been brought to a very satisfactory state of exactness. A student can now analyze with ease substances that would have perplexed the professor of fifty years ago. Aside from the immense advance in our knowledge of chemical causes and effects made by this powerful lever placed at our disposal, the public has been afforded a most marked protection against fraud and imposition. No matter how high-sounding and laudatory the announcement of certain articles may appear, the cold-blooded analysis of the chemist at once dispels the illusion. There is no lack of unscrupulous persons who take advantage of many a chemical discovery to fill their own pockets at the expense of the public. The extent to which adulteration is carried to-day cannot be conceived of by one who is not conversant with the results of the analysis of commercial articles. Indeed, the popular ignorance on this subject is astounding. The continual demand by the public for cheap articles drives the manufacturers to all sorts of ways and means to adulterate. To counteract this, boards of health are continually analyzing articles of food. But commercial articles, however, are, as a rule, examined only by those who know how a chemical analysis can protect the buyer. Some years ago New York paid $10,000 a day for the water added to the milk sold in that city. In every city one will find many articles of daily use are systematically adulterated. The time will come when every city will have to have its board of public analysts, who shall analyze all articles free of charge. Such boards exist now in France and Germany, and the results of their work throws a somber light on the strivings of human cupidity. Cream of tartar often contains as high as 80 per cent of adulteration, illuminating oils are not seldom about as safe as gunpowder, soaps may be one-half water, borax is sometimes mostly baking soda. In the matter of fertilizers the State experiment stations examine free of charge all articles, and determine their true value, but hundreds of other articles should also be tested by the government that the public may be protected. Slowly but surely the keen weapon of chemical analysis is lopping off all these unsightly side-shoots of our civilization. As long as food and drink consist of chemical substances and so many of the articles bought and sold are chemical compounds, it should be known to what extent they are what they are claimed to be.

What is the effect of the increasing accuracy in chemical analysis upon our civilization? It places every article on its true basis of intrinsic worth. Metals, ores and articles of commerce, have a certain value depending on the nature and amount of their valuable constituents. This is determined by analysis, and business is at once placed upon a solid foundation, and insecurity in values ceases. Chemical analysis is the balance wheel of trade. It establishes responsibility. It says to the cheat, honored and respected though he may be in the community—and there are thousands of them—"Thou art the man." It compels accuracy of statement—rigid truth. There is no effervescent sentiment in a chemical analysis. It makes honesty compulsory. Articles of food and drink must be what they claim to be, no more, no less. A man who adulterates is a liar and a thief, if not also a coward. He may cause ruin, disaster and death. A man who buys adulterated articles is a fool. Chemical analysis is one of the greatest agents for the protection of a community that there is, and its power is increasing every day. Again note: Chemical analysis shows clearly which of several articles are the best. Then we will buy that article that we know to be the best. And so chemical analysis, disclosing to the world where true worth is to be found, develops countries and gives them resources which may enable them to compete with greater nations. It shows us the relations between the material objects about us, and our own relations to them. For instance, the atmosphere, which is necessary to our existence, is composed of oxygen and nitrogen. The oxygen is being continually consumed and appears again as carbonic acid, the results of fires, fermentation and the respiration of animals. The plants consume the carbonic acid and give back the oxygen again to a great extent. There are thousands of these agents at work to change the composition of the air. And yet its composition does not practically vary. Should it, however, then life would feel the change at once. An increase of the percentage of oxygen in the air we breathe would produce a marked effect upon us. It is wonderful that the balance of these conditions is kept in such equilibrium on such a scale.

(To be concluded.)

* This was written before Loch's new ideas were advanced.

† This prediction made but a few years ago is now verified. The grazing lands of the West are about exhausted.

‡ Past, Present and Future of Scientific Agriculture. An address delivered before the N. J. State Board of Agriculture by Peter T. Austen.

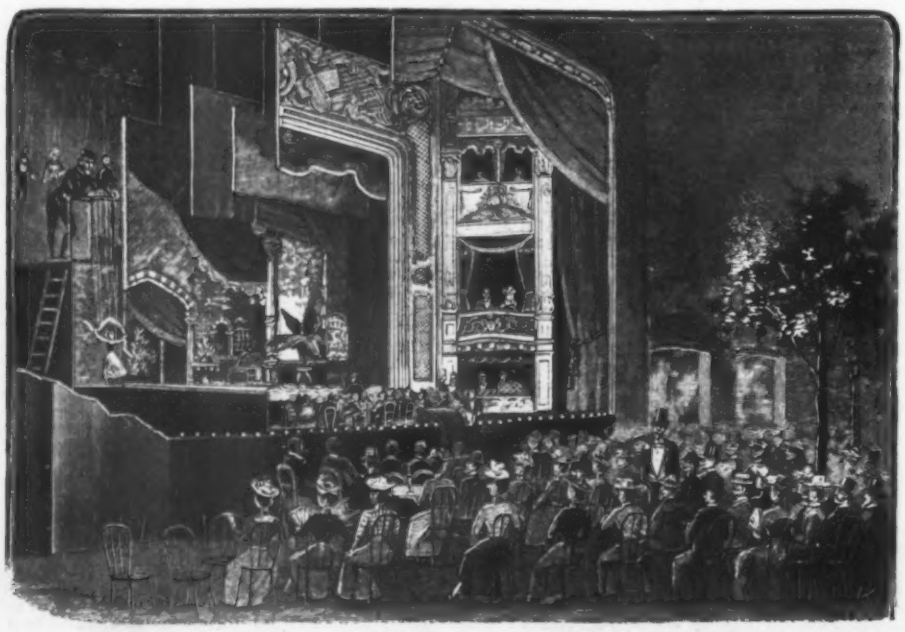


FIG. 1.—M. DE SAINT-GENOIS' PUPPET THEATER.

A PARISIAN PUPPET THEATER.

THE puppet is so ancient that it did not seem possible that any one could improve it; yet M. de Saint-Genois set about the task and has succeeded in making his figures live with such reality that the spectator immediately recognizes the persons that they represent by their action and gait and even by the expression of their countenance. The means that he employs are not complicated, and it is the result of detailed observations especially that, through simple threads attached at the proper places, he has succeeded in giving life to his puppets, which he actuates singly and in most cases with one hand. His method of presenting them is not common-place, as may be seen at the Jardin des Plantes, where he has constructed not only a stage adapted to the stature (about 2.75 feet) of his actors, but an entire theater with its curtain and drop-scene and even its orchestra. In the boxes he has installed male and female spectators which toy with opera-glasses and fans, and the motions of the arms and head of which seem very natural. As for the leader of the orchestra, he exerts himself conscientiously, according to the rules of his calling, and all of his musicians are full of action. One would be willing to wager that it was they who were accompanying the singer. All this proceeds solely through the will of John Hewelt (pseudonym of M. de Saint-Genois), who, standing upon a platform overlooking his theater (Fig. 1), has all the threads under his hands and feet.

In order to give life to a puppet, there must be no hesitation about attaching the necessary number of threads to it. What is necessary afterward is the ability to work them, and that depends greatly upon the points of attachment of the various threads used in manipulation. It must not be forgotten that the

motions of living beings, and especially of actors, are very complex, and all or almost all of these it is necessary to try to reproduce. This explains the multiplicity of the threads necessary for the actuating of a single puppet (Fig. 2), and a still greater number of which may be added if, as in the "Gringalets" exhibited by M. de Saint-Genois at El Dorado, we wish to obtain a play of the features of a figure more than three feet in height and the head of which is nearly of natural size. In this case, it is necessary to obtain a movement of the eyes and mouth and even of the cheeks; and all this is possible. The only precaution to be taken is to keep the threads from getting entangled. With this object in view, M. de Saint-Genois has devised a peculiar method of attachment. He divides the threads into several series, one of which controls the legs, a second the arms, and a third the trunk, while a fourth, when need be, effects particular motions. Each series of threads is connected with a rod about fifteen inches in length, and each thread is attached to a determinate part of it. Those used for actuating the lower part of the legs are at the extremities, so that if the rod be held by the center, a slight inclination will correspond to considerable of displacement. As a general thing, the operator holds the three rods in one hand, and it is by a variation in the inclination of each of them, or by pulling one or more of the threads with the fingers that he succeeds in giving life to his puppet. It is evident that the art of doing this cannot be acquired in a day. It requires the exercise of a great deal of observation in order to succeed in imitating to perfection such or such a political or official individual, or some artist or others well known to frequenters of the theater.

The entire installation under consideration occupies but little space, and, when exhibited in a theater, is easily put upon the stage at the proper moment. But it can also be easily set up in a parlor for affording amusement at soirées, of which dancing is not the principal feature.—Translated for the SCIENTIFIC AMERICAN SUPPLEMENT from La Nature.

THE PROTECTED CRUISER "DES MOINES."*

THE protected cruiser "Des Moines," which was successfully launched at the Fore River yard near Boston on Saturday, September 20, is one of six sheathed and coppered cruisers authorized by act of Congress of March 3, 1899, being intended chiefly for the protection of American interests in foreign ports. The contract for the construction of her hull and engines was signed with the Fore River Ship and Engine Company, of Quincy, Mass., in Boston Harbor, on December 14, 1899, and her keel was laid August 28, 1900. The "Des Moines" has a load waterline of 292 feet, an extreme length of 308 feet 2 inches, a breadth of 44 feet, a mean draught of 15 feet 9 inches, a normal displacement of 3,200 tons, and a full-load displacement of 3,500 tons. Her estimated speed, with 4,700 indicated horse power, will be 16½ knots. Her normal coal supply is 467 tons, but her full bunker capacity is 700 tons, which is sufficient to give her a steaming radius of 2,600 miles at full speed, or 9,800 miles at 10 knots an hour. She has two vertical, inverted, triple-expansion, four-cylinder engines, six water-tube boilers, a grate surface of 300 square feet, and two stacks set fore and aft, rising 70 feet above the grates. The boilers and some of the auxiliary engines were installed before the launching.

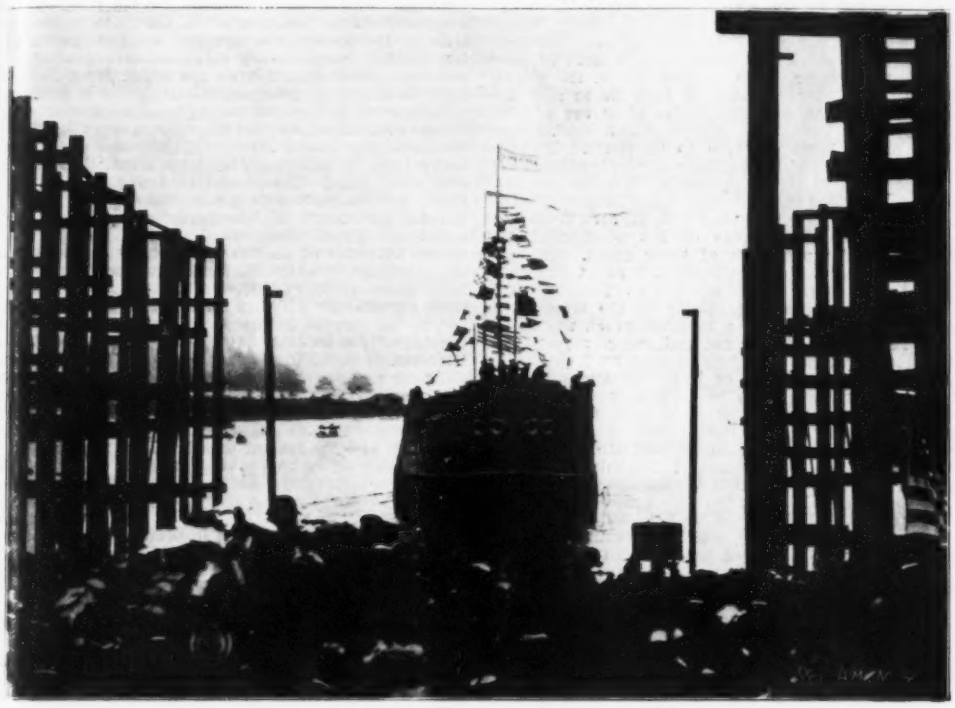
The submerged portion of the hull of the "Des Moines" is sheathed with Georgia pine planks, bolted to the steel skin with 23,000 bronze bolts, and to be covered with sheet copper. The twin screws, rudder, stem, and stern castings, and all out-board parts, are of bronze. Teak has been used for the keel, oak for the bilge keels. She will have a non-magnetic pilot house of bronze. When the Bureau of Construction and Repair decided upon the bronze bolts which would be required, it was discovered that bolts of this character were not carried in stock, and that no machinery existed for making them. Therefore, it was necessary to delay the work until machines could be devised for turning out these bronze fastenings with sufficient rapidity.

The sheathing was done with great care, and so successfully that it is pronounced by naval experts as one of the best jobs of the kind on record.

The cruiser will be well armed for her size. The main battery will consist of ten 5-inch, 50-caliber, breech-loading, rapid-fire guns, and the secondary battery will comprise eight 6-pounder rapid-fire guns, two 1-pounder rapid-fire guns, four Colt automatic guns, and one 3-inch field gun. The guns will all be designed for smokeless powder, so that the 5-inch guns will be more effective than the old 6-inch guns using black powder. Eight of the 5-inch guns will be mounted on the gun deck in recessed ports; the two forward ones having a range from right forward to 60 degrees abaft the beam, and the two after ones from right aft to 60 degrees before the beam, while the four waist guns will have a range from 60 degrees before to 60 degrees abaft the beam. The two remaining 5-inch guns will be located behind shields on the spar deck, one forward and one aft. Four 6-pounders will be mounted on the gun deck and four more on the spar deck; the two 1-pounders will be mounted aft on the gun deck and the Colt machine guns on the top of the hammock berthing amidships. The ammunition supply will be large in order to make the rapid-fire guns effective, comprising 250 rounds for each of the 5-inch guns, and 500 rounds for each of the 6-pounders.

The "Des Moines" will have two masts, fore and aft rigged, carrying 6,000 square feet of canvas. She will carry a full electrical equipment for lights and power, including two search lights, deck hoists and an engine-turning motor. Her foremast will have an attachment for wireless telegraphy. She will also have ice-making and evaporating installations. All the bulkheads on the gun and berth decks will be of metal, and where it is necessary to use wood for any purpose, it is to be treated with an electric fireproof process before being worked. A water-tight or protective deck has been worked from stem to stern, the sides sloping down to three feet below the water line. This deck is five-sixteenths of an inch thick on the flat and from one-half to two and one-half inches thick on the slopes, the greatest thickness, of nickel steel, being abreast the engines and boilers. Above the water-tight deck, covering the water line from stem to stern, is an obturating belt, composed of about 6,720 cubic feet of cornpith cellulose. All the propelling machinery, steering gear, and magazines will be below the water-tight deck.

The cruiser will carry one 30-foot launch, four 28-foot cutters, one 28-foot gig whaleboat, one 28-foot whaleboat, one 20-foot dinghy, and one 16-foot dinghy. The contract price for hull and machinery is $1,065,000, the armament being supplied by the government. The "Des Moines" was launched from the same ways which the Fore River Company recently used in launching the seven-masted schooner, "Thomas W. Lawson," the largest American sailing ship afloat.



LAUNCH OF THE "DES MOINES" AT THE FORE RIVER YARDS.

*Especially written for the SCIENTIFIC AMERICAN SUPPLEMENT.

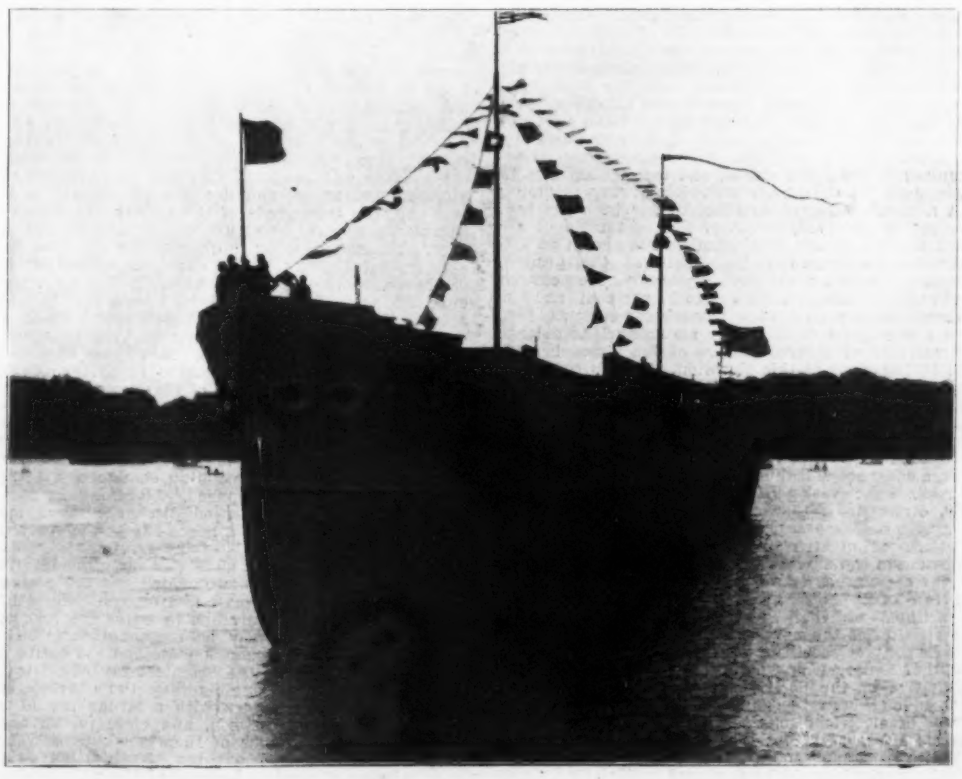
DREDGING FOR GOLD.

DREDGING for gold is carried on more successfully in New Zealand than in any other portion of the world, and at the present time nearly a hundred dredges are there at work on the gravels of different rivers, most of them successfully, many earning dividends ranging from 100 to 200 per cent.

In dealing with dredging propositions care must be taken in the preliminary prospecting operations to become thoroughly acquainted with the nature of the bed-rock. This is most important, and in nearly every instance governs the chances of success in using dredges for placer mining. Should the bed-rock be found of such a nature that the lips of the dredge buckets cannot easily cut or scrape it, one may be assured that it will be impossible to recover the best, or bed-rock values, contained in the gravels. There are some large tracts of alluvial deposits suitable for dredging that will, on prospecting, show sufficient values from surface to bed-rock to warrant the installation of a dredge, even should the bed-rock values be impossible to recover; but great care and thorough prospecting ought to be carried out on a liberal scale before attempting to work such deposits by this method.

Many types of dredges are now on the market for working placer deposits—clam shell dredges, the steam shovel kind, Archimedean screws, bucket and ladder dredges, and others; but of all these the bucket and ladder dredge, in the writer's opinion, is the best machine for this particular service.

In New Zealand, where all classes of mining receive valuable aid in the way of subsidies from the government, this method of dredging the placers has been in vogue for over twenty years, and during that period every class of dredge has received a thorough practical test, at the cost of large sums of money, and at the present time one will see nothing but the bucket and ladder type, with mechanical stakers for taking care of the tailings, successfully treating the gravels. It is certainly no compliment to the ingenuity or business abilities of manufacturers of dredging machinery to find them inventing and manufacturing the many different and similar kinds of machines that have been liberally and practically tried and proved failures by the dredging faculty of New Zealand years ago; yet there are evidences enough in California, Idaho, Montana and other parts of the United States



THE SEMI-PROTECTED CRUISER "DES MOINES."

Displacement, 3,200 tons. Speed, 16½ knots. Maximum coal supply, 700 tons. Protection: Deck ⅞ inch on flat and 2½ inches on slopes amidship. Armament: Ten 5-inch, eight 6-pounders, two 1-pounders. Complement, 290.

of failures entirely due to the installation of unsuitable machines. It is not claimed that the New Zealand type of dredge is a perfect one; but it is the result of experience gained by many years of practical working and of trials of everything in the shape of a dredge that came along.

The most important faults in connection with dredges of the present day are in connection with the gold-saving appliances. With few exceptions these are of the crudest kind, the makers apparently using all their endeavors toward designing machines for digging capacity and allowing the gold-saving or most important end of the dredge to take care of itself.

[Continued from Supplement No. 1397, page 22387.]

HISTORY OF COLD AND THE ABSOLUTE ZERO.*

By Prof. James Dewar.

According to the old law of Dalton, supported by the modern dynamical theory of gases, each constituent of the atmosphere while acted upon by the force of gravity forms a separate atmosphere, completely independent, except as to temperature, of the others, and the relations between the common temperature and the pressure and altitude for each specific atmosphere can be definitely expressed. If we assume the altitude and temperature known, then the pressure can be ascertained for the same height in the case of each of the gaseous constituents, and in this way the percentage composition of the atmosphere at that place may be deduced. Suppose we start with a surface atmosphere having the composition of our air, only containing two ten-thousandths of hydrogen, then at thirty-seven miles, if a sample could be procured for analysis, we believe that it would be found to contain 12 per cent of hydrogen and only 10 per cent of oxygen. The carbonic acid practically disappears; and by the time we reach forty-seven miles, where the temperature is minus 132 degrees, assuming a gradient of 3.2 degrees per mile, the nitrogen and oxygen have so thinned out that the only constituent of the upper air which is left is hydrogen. If the gradient of temperature were doubled, the elimination of the nitrogen and oxygen would take place by the time thirty-seven miles was reached, with a temperature of minus 220 degrees. The permanence of the composition of the air at the highest altitudes, as deduced from the basis of the dynamical theory of gases, has been discussed by Stoney, Bryan and others. It would appear that there is a consensus of opinion that the rate at which gases like hydrogen and helium could escape from the earth's atmosphere would be excessively slow. Considering that to compensate any such loss the same gases are being supplied by actions taking place in the crust of the earth, we may safely regard them as necessarily permanent constituents of the upper air. The temperature at the elevations we have been discussing would not be sufficient to cause any liquefaction of the nitrogen and oxygen, the pressure being so low. If we assume the mean temperature as about the boiling point of oxygen at atmospheric pressure, then a considerable amount of the carbonic acid must solidify as a mist, if the air from a lower level be cooled to this temperature; and the same result might take place with other gases of relatively small volatility which occur in air. This would explain the clouds that have been seen at an elevation of fifty miles, without assuming the possibility of water vapor being carried up so high. The temperature of the upper air must be above that on the vapor pressure curve corresponding to the barometric pressure at the locality, otherwise liquid condensation must take place. In other words, the temperature must be above the dew point of air at that place. At higher elevations, on any reasonable assumption of temperature distribution, we inevitably reach a temperature where the air would condense, just as Fourier and Poisson supposed it would, unless the temperature is arrested in some way from approaching the zero. Both ultra-violet absorption and the prevalence of electric storms may have something to do with the maintenance of a higher mean temperature. The whole mass of the air above forty miles is not more than one seven-hundredth part of the total mass of the atmosphere, so that any rain or snow of liquid or solid air, if it did occur, would necessarily be of a very tenuous description. In any case, the dense gases tend to accumulate in the lower strata, and the lighter ones to predominate at the higher altitudes, always assuming that a steady state of equilibrium has been reached. It must be observed, however, that a sample of air taken at an elevation of nine miles has shown no difference in composition from that at the ground, whereas, according to our hypothesis, the oxygen ought to have been diminished to 17 per cent, and the carbonic acid should also have become much less. This can only be explained by assuming that a large intermixture of different layers of the atmosphere is still taking place at this elevation. This is confirmed by a study of the motions of clouds about six miles high, which reveals an average velocity of the air currents of some seventy miles an hour; such violent winds must be the means of causing the intermingling of different atmospheric strata. Some clouds, however, during hot and thundery weather, have been seen to reach an elevation of seventeen miles, so that we have direct proof that on occasion the lower layers of atmosphere are carried to a great elevation. The existence of an atmosphere at more than a hundred miles above the surface of the earth is revealed to us by the appearance of meteors and fireballs, and when we can take photographs of the spectrum of such apparitions we shall learn a great deal about the composition of the upper air. In the meantime Pickering's solitary spectrum of a meteor reveals an atmosphere of hydrogen and helium, and so far this is corroborative of the doctrine we have been discussing. It has long been recognized that the aurora is the result of electric discharges within the limits of the earth's atmosphere, but it was difficult to understand why its spectrum should be so entirely different from anything which could be produced artificially by electric discharges through rarefied air at the surface of the earth. Writing in 1879, Rand Capron, after collecting all the recorded observations, was able to enumerate no more than nine auroral rays, of which but one could with any probability be identified with rays emitted by atmospheric air under an electric discharge. Vogel attributed this want of agreement between nature and experiment, in a vague way, to difference of temperature and pressure; and Zollner thought the auroral spectrum to be one of a different order, in the sense in which the line and band spectra of nitrogen are said to be of different orders. Such statements were merely confessions of ignorance. But since that time observations of the spectra of auroras have been greatly multiplied, chiefly through the Swedish and Danish Polar Expeditions, and the length of spectrum recorded on the ultra-violet side has been greatly extended by the use of photography, so that, in a recent discussion of the results, M. Henri Stassano is able to enumerate upward of one hundred auroral rays, of which the wave-length is more or less approximately known, some of them far in the ultra-violet. Of this large number of rays he is able to identify, within the probable limits of errors of observation, about two-thirds as rays, which Prof. Liveing and myself have observed to be emitted by the most volatile gases of atmospheric air unliquefiable at the temperature of liquid hydrogen. Most of the remainder he ascribes to argon, and some he might, with more probability, have identified with krypton or xenon rays, if he had been aware of the publication of wave-lengths of the spectra of those gases, and the identification of one of the highest rays of krypton with that most characteristic of auroras. The rosy tint often seen in auroras, particularly in the streamers, appears to be due mainly to neon, of which the spectrum is remarkably rich in red and orange rays. One or two neon rays are among those most frequently observed, while the red ray of hydrogen and one red ray of krypton have been noticed only once. The predominance of neon is not surprising, seeing that from its relatively greater proportion in air and its low density it must tend to concentrate at higher elevations. So large a number of probable identifications warrants the belief that we may yet be able to reproduce in our laboratories the auroral spectrum in its entirety. It is true that we have still to account for the appearance of some, and the absence of other, rays of the newly discovered gases, which in the way in which we stimulate them appear to be equally brilliant, and for the absence, with one doubtful exception, of all the rays of nitrogen. If we cannot give the reason of this, it is because we do not know the mechanism of luminescence—nor even whether the particles which carry the electricity are themselves luminous, or whether they only produce stresses causing other particles which encounter them to vibrate; yet we are certain that an electric discharge in a highly rarefied mixture of gases lights one element and not another, in a way which, to our ignorance, seems capricious. The Swedish North Polar Expedition concluded from a great number of trigonometrical measurements that the average above the ground of the base of the aurora was fifty kilometers (thirty-four miles) at Cape Thorsden, Spitzbergen; at this height the pressure of the nitrogen of the atmosphere would be only about one-tenth of a millimeter and Moissan and Deslandres have found that in atmospheric air at pressures less than one millimeter the rays of nitrogen and oxygen fade and are replaced by those of argon and by five new rays which Stassano identifies with rays of the more volatile gases measured by us. Also Collie and Ramsay's observations on the distance to which electrical discharges of equal potential traverse different gases explosively throw much light on the question; for they find that, while for helium and neon this distance is from 250 to 300 mm., for argon it is 45½ mm., for hydrogen it is 39 mm., and for air and oxygen still less. This indicates that a good deal depends on the very constitution of the gases themselves, and certainly helps us to understand why neon and argon, which exist in the atmosphere in larger proportions than helium, krypton or xenon, should make their appearance in the spectrum of auroras almost to the exclusion of nitrogen and oxygen. How much depends, not only on the constitution and it may be temperature of the gases, but also on the character of the electric discharge, is evident from the difference between the spectra at the cathode and anode in different gases, notably in nitrogen and argon, and not less remarkably in the more volatile compounds of the atmosphere. Paulsen thinks the auroral spectrum wholly due to cathodic rays. Without stopping to discuss that question, it is certain that changes in the character of the electric discharge produce definite changes in the spectra excited by them. It has long been known that in many spectra the rays which are inconspicuous with an uncondensed electric discharge become very pronounced when a Leyden jar is in the circuit. This used to be ascribed to a higher temperature in this condensed spark, though measurements of that temperature have not borne out the explanation. Schuster and Hemsalech have shown that these changes of spectra are in part due to the oscillatory character of the condenser discharge which may be enhanced by self-induction, and the corresponding change of spectrum thereby made more pronounced. Lightning we should expect to resemble condensed discharge much more than aurora, but this is not borne out by the spectrum. Pickering's recent analysis of the spectrum of a flash obtained by photography shows, out of nineteen lines measured by him, only two which can be assigned with probability to nitrogen and oxygen, while three hydrogen rays most likely due to water are very conspicuous, and eleven may be reasonably ascribed to argon, krypton and xenon, one to more volatile gas of the neon class, and the brightest ray of all is but a very little less refrangible than the characteristic auroral ray, and coincides with a strong ray of calcium, but also lies between, and close to, an argon and a neon ray, neither of them weak rays. There may be some doubt about the identification of the spectral rays of auroras because of the wide limits of the probable errors in measuring wave-lengths so faint as most of them are, but there is no such doubt about the wave-lengths of the rays in solar protuberances measured by Deslandres and Hale. Stassano found that these rays, forty-four in number, lying between the Fraunhofer line F and 3148 in the ultra-violet, agree very closely with rays which Prof. Liveing and myself measured in the spectra of the most volatile atmospheric gases. It will be remembered that one of the earliest suggestions as to the nature of solar prominences was that they were solar auroras. This supposition helped to explain the marvelous rapidity of their changes, and the apparent suspension of brilliant self-luminous clouds at enormous heights above the sun's surface. Now the identification of the rays of their spectra with those of the most volatile gases, which also furnish many of the auroral rays, certainly supports that suggestion. A stronger support, however, seems to be given to it by the results obtained at the total eclipse of May, 1901, by the American expedition to Sumatra. In the Astrophysical Journal for June last is a list of 339 lines in the spectrum of the corona photographed by Humphreys, during totality, with a very large concave grating. Of these no fewer than 209 do not differ from lines we have measured in the most volatile gases of the atmosphere, or in krypton or xenon, by more than one unit of wave-length on Angström's scale, a quantity within the limit of probable error. Of the remainder, a good many agree to a like degree with argon lines, a very few with oxygen lines and still fewer with nitrogen lines, the characteristic green auroral ray, which is not in the range of Humphrey's photographs, also agrees within a small fraction of a unit of wave-length with one of the rays emitted by the most volatile atmospheric gas. Taking into account the Fraunhofer lines, *H*, *K* and *G*, usually ascribed to calcium, there remain only fifty-five lines of the 339 unaccounted for to the degree of probability indicated. Of these considerably more than half are very weak lines, which have not depicted themselves on more than one of the six films exposed, and extend but a very short distance into the sun's atmosphere. There are, however, seven which are stronger lines, and reach to a considerable height above the sun's rim, and all have depicted themselves on at least four of the six films. If there be no considerable error in the wave-lengths assigned (and such is not likely to be the case), these lines may perhaps be due to some volatile element which may yet be discovered in our atmosphere. However that may be, the very great number of close coincidences between the auroral rays and those which are emitted under electric excitement by gases of our atmosphere almost constrains us to believe, what is indeed most probable on other grounds, that the sun's coronal atmosphere is composed of the same substances as the earth's, and that it is rendered luminous in the same way—namely, by electric discharges. This conclusion has plainly an important bearing on the explanation which should be given of the outburst of new stars and of the extraordinary and rapid changes in their spectra. Moreover, leaving on one side the question whether gases ever become luminous by the direct action of heat, apart from such transfers of energy as occur in chemical change and electric disturbance, it demands a revision of the theories which attribute more permanent differences between the spectra of different stars to differences of temperature, and a fuller consideration of the question whether they cannot with better reason be explained by differences in the electric conditions which prevail in the stellar atmosphere.

If we turn to the question what is the cause of the electric discharges which are generally believed to occasion auroras, but of which little more has hitherto been known than that they are connected with sunspots and solar eruptions, recent studies of electric discharges in high vacua, with which the names of Crookes, Röntgen, Lenard, and J. J. Thomson will always be associated, have opened the way for Arrhenius to suggest a definite and rational answer. He points out that the frequent disturbances which we know to occur in the sun must cause electric discharges in the sun's atmosphere far exceeding any that occur in that of the earth. These will be attended with an ionization of the gases, and the negative ions will stream away through the outer atmosphere of the sun into the interplanetary space, becoming, as Wilson has shown, nuclei of aggregation of condensable vapors and cosmic dust. The liquid and solid particles thus formed will be of various sizes; the larger will gravitate back to the sun, while those with diameters less than one and a half thousandths of a millimeter, but nevertheless greater than a wave-length of light, will, in accordance with Clerk-Maxwell's electromagnetic theory, be driven away from the sun by the incidence of the solar rays upon them, with velocities which may become enormous, until they meet other celestial bodies, or increase their dimensions by picking up more cosmic dust or diminish them by evaporation. The earth will catch its share of such particles on the side which is turned toward the sun, and its upper atmosphere will thereby become negatively electrified until the potential of the charge reaches such a point that a discharge occurs, which will be repeated as more charged particles reach the earth. This theory not only accounts for the auroral discharges, and the coincidence of their times of greatest frequency with those of the maxima of sunspots, but also for the minor maxima and minima. The vernal and autumnal maxima occur when the line through the earth and sun has its greatest inclination to the solar equator, so that the earth is more directly exposed to the region of maximum of sunspots, while the twenty-six days period corresponds closely with the period of rotation of that part of the solar surface where faculæ are most abundant. J. J. Thomson has pointed out, as a consequence of the Richardson observations, that negative ions will be constantly streaming from the sun merely regarded as a hot body, but this is not inconsistent with the supposition that there will be an excess of this emission in eruptions, and from the regions of faculæ. Arrhenius' theory accounts also, in a way which seems the most satisfactory hitherto enunciated, for the appearances presented by comets. The solid parts of these objects absorb the sun's rays, and as they approach the sun become heated on the side turned toward him until the volatile substances frozen in or upon them are evaporated and diffused in the gaseous state in surrounding space, where they get cooled to the temperature of liquefaction and aggregated in drops about the negative ions. The larger of these drops gravitate toward

* Abstract of a Presidential Address delivered at the Belfast meeting on September 10, 1902, of the British Association for the Advancement of Science.

the sun and form clouds of the coma about the head, while the smaller are driven by the incidence of the sun's light upon them away from the sun and form the tail. The curvature of the tail depends, as Bredichin has shown, on the rate at which the particles are driven, which in turn depends on the size and specific gravity of the particles, and these will vary with the density of the vapor from which they are formed, and the frequency of the negative ions which collect them. In any case Arrhenius' theory is a most suggestive one, not only with reference to auroras and comets, and the solar corona and chromosphere, but also as to the constitution of the photosphere itself.

VARIOUS LOW TEMPERATURE RESEABCHES.

We may now summarize some of the results which have already been attained by low-temperature studies. In the first place, the great majority of chemical interactions are entirely suspended, but an element of such exceptional powers of combination as fluorine is still active at the temperature of liquid air. Whether solid fluorine and liquid hydrogen would interact no one can at present say. Bodies naturally become denser, but even a highly expansive substance like ice does not appear to reach the density of water at the lowest temperature. This is confirmatory of the view that the particles of matter under such conditions are not packed in the closest possible way. The force of cohesion is greatly increased at low temperatures, as is shown by the additional stress required to rupture metallic wires. This fact is of interest in connection with two conflicting theories of matter. Lord Kelvin's view is that the forces that hold together the particles of bodies may be accounted for without assuming any other agency than gravitation or any other law than the Newtonian. An opposite view is that the phenomena of the aggregation of molecules depend upon the molecular vibration as a physical cause. Hence, at the zero of absolute temperature, this vibrating energy being in complete abeyance, the phenomena of cohesion should cease to exist, and matter generally be reduced to an incoherent heap of cosmic dust. This second view receives no support from experiment.

The photographic action of light is diminished at the temperature of liquid air to about 20 per cent of its ordinary efficiency, and at the still lower temperature of liquid hydrogen only about 10 per cent of the original sensitivity remains. At the temperature of liquid air or liquid hydrogen a large range of organic bodies and many inorganic ones acquire under exposure to violet light the property of phosphorescence. Such bodies glow faintly so long as they are kept cold, but become exceedingly brilliant during the period when the temperature is rising. Even solid air is a phosphorescent body. All the alkaline earth sulphides which phosphoresce brilliantly at the ordinary temperature lose this property when cooled, to be revived on heating; but such bodies in the first instance may be stimulated through the absorption of light at the lowest temperatures. Radio-active bodies, on the other hand, like radium, which are naturally self-luminous, maintain this luminosity unimpaired at the very lowest temperatures, and are still capable of inducing phosphorescence in bodies like the platino-cyanides. Some crystals become for a time self-luminous when cooled in liquid air or hydrogen, owing to the induced electric stimulation causing discharges between the crystal molecules. This phenomenon is very pronounced with nitrate of uranium and some platino-cyanides.

In conjunction with Prof. Fleming a long series of experiments was made on the electric and magnetic properties of bodies at low temperatures. The subjects that have been under investigation may be classified as follows: The Thermo-Electric Powers of Pure Metals; the Magnetic Properties of Iron and Steel; Dielectric Constants; the Magnetic and Electric Constants of Liquid Oxygen; Magnetic Susceptibility.

The investigations have shown that electric conductivity in pure metals varies almost inversely as the absolute temperature down to *minus* 200 degrees, but that this law is greatly affected by the presence of the most minute amount of impurity. Hence the results amount to a proof that electric resistance in pure metals is closely dependent upon the molecular or atomic motion which gives rise to temperature, and that the process by which the energy constituting what is called an electric current is dissipated essentially depends upon non-homogeneity of structure and upon the absolute temperature of the material. It might be inferred that at the zero of absolute temperature resistance would vanish altogether, and all pure metals become perfect conductors of electricity. This conclusion, however, has been rendered very doubtful by subsequent observations made at still lower temperatures, which appear to point to an ultimate finite resistance. Thus the temperature at which copper was assumed to have no resistance was *minus* 223 degrees, but that metal has been cooled to *minus* 253 degrees without getting rid of all resistance. The reduction in resistance of some of the metals at the boiling-point of hydrogen is very remarkable. Thus copper has only 1 per cent, gold and platinum 3 per cent, and silver 4 per cent of the resistance they possessed at zero C., but iron still retains 12 per cent of its initial resistance. In the case of alloys and impure metals, cold brings about a much smaller decrease in resistivity, and in the case of carbon and insulators like gutta-percha, glass, ebonite, etc., their resistivity steadily increases. The enormous increase in resistance of bismuth when transversely magnetized and cooled was also discovered in the course of these experiments. The study of dielectric constants at low temperatures has resulted in the discovery of some interesting facts. A fundamental deduction from Maxwell's theory is that the square of the refractive index of a body should be the same number as its dielectric constant. So far, however, from this being the case generally, the exceptions are far more numerous than the coincidences. It has been shown in the case of many substances, such as ice and glass, that an increase in the frequency of the alternating electromotive force results in a reduction of the dielectric constant to a value more consistent with Maxwell's law. By experiments upon many substances it is shown that even a moderate increase of frequency brings the large dielectric constant to values quite near to that required by Maxwell's law. It was thus shown that low temperature has the same effect as high frequency in annulling the abnormal dielectric values. The exact measurement of the dielectric constant of liquid oxygen as well as its magnetic permeability, combined with the optical determination of the refractive index, showed that liquid oxygen strictly obeys Maxwell's electro-optic law even at very low electric frequencies. In magnetic work the result of greatest value is the proof that magnetic susceptibility varies inversely as the absolute temperature. This shows that the magnetization of paramagnetic bodies is an affair of orientation of molecules, and it suggests that at the absolute zero all the feebly paramagnetic bodies will be strongly magnetic. The diamagnetism of bismuth was found to be increased at low temperatures. The magnetic moment of a steel magnet is temporarily increased by cooling in liquid air, but the increase seems to have reached a limit, because on further cooling to the temperature of liquid hydrogen hardly any further change was observed. The study of the thermo-electric relations of the metals at low temperatures resulted in a great extension of the well-known Tait Thermo-Electric Diagram. Tait found that the thermo-electric power of the metals could be expressed by a linear function of the absolute temperature, but at the extreme range of temperature now under consideration this law was found not to hold generally; and further, it appeared that many abrupt electric changes take place, which originate probably from specific molecular changes occurring in the metal. The thermo-electric neutral points of certain metals, such as lead and gold, which are located about or below the boiling-point of hydrogen, have been found to be a convenient means of defining specific temperatures in this exceptional part of the scale.

The effect of cold upon the life of living organisms is a matter of great intrinsic interest, as well as of wide theoretical importance. Experiment indicates that moderately high temperatures are much more fatal, at least to the lower forms of life, than are exceedingly low ones. Prof. McKendrick froze for an hour at a temperature of 182 deg. C. samples of meat, milk, etc., in sealed tubes; when these were opened after being kept at blood heat for a few days, their contents were found to be quite putrid. More recently some more elaborate tests were carried out at the Jenner Institute of Preventive Medicine on a series of typical bacteria. These were exposed to the temperature of liquid air for twenty hours, but their vitality was not affected, their functional activities remained unimpaired, and the cultures which they yielded were normal in every respect. The same result was obtained when liquid hydrogen was substituted for air. A similar persistence of life in seeds has been demonstrated even at the lowest temperatures; they were frozen for over a hundred hours in liquid air, at the instance of Messrs. Brown and Escombe, with no other result than to affect their protoplasm with a certain inertness, from which it recovered with warmth. Subsequently commercial samples of barley, pea, vegetable-marrow and mustard seeds were literally steeped for six hours in liquid hydrogen at the Royal Institution, yet when they were sown by Sir W. T. Thiselton-Dyer, at Kew, in the ordinary way, the proportion in which germination occurred was no less than in the other batches of the same seeds which had suffered no abnormal treatment. Bacteria are minute vegetable cells, the standard of measurement for which is the "mikron." Yet it has been found possible to completely triturate these microscopic cells, when the operation is carried out at the temperature of liquid air, the cells then being frozen into hard, breakable masses. The typhoid organism has been treated in this way, and the cell plasma obtained for the purpose of studying its toxic and immunizing properties. It would hardly have been anticipated that liquid air should find such immediate application in biological research. A research by Prof. Macfadyen, just concluded, has shown that many varieties of micro-organisms can be exposed to the temperature of liquid air for a period of six months without any appreciable loss of vitality, although at such a temperature the ordinary chemical processes of the cell must cease. At such a temperature the cells cannot be said to be either alive or dead, in the ordinary acceptation of these words. It is a new and hitherto unobtained condition of living matter—a third state. A final instance of the application of the above methods may be given. Certain species of bacteria during the course of their vital processes are capable of emitting light. If, however, the cells be broken up at the temperature of liquid air, and the crushed contents brought to the ordinary temperature, the luminosity function is found to have disappeared. This points to the luminosity not being due to the action of a ferment—a "Luciferase"—but as being essentially bound up with the vital processes of the cells, and dependent for its production on the intact organization of the cell. These attempts to study by frigorific methods the physiology of the cell have already yielded valuable and encouraging results, and it is to be hoped that this line of investigation will continue to be vigorously prosecuted at the Jenner Institute.

And now, to conclude an address which must have sorely taxed your patience, I may remind you that I commenced by referring to the plaint of Elizabethan science, that cold was not a natural available product. In the course of a long struggle with nature, man, by the application of intelligent and steady industry, has acquired a control over this agency which enables him to produce it at will, and with almost any degree of intensity, short of a limit defined by the very nature of things. But the success in working what appears, at first sight, to be a quarry of research that would soon suffer exhaustion, has only brought him to the threshold of new labyrinths, the entanglements of which frustrate, with a seemingly invulnerable complexity, the hopes of further progress. In a legitimate sense all genuine scientific workers feel that they are "the inheritors of unfulfilled renown." The battlefields of science are the centers of a perpetual warfare in which there is no hope of final victory, although partial conquest is ever triumphantly encouraging the continuance of the disciplined and strenuous attack on the seemingly impregnable fortress of Nature. To serve in the scientific army, to have shown some initiative, and to be rewarded by the consciousness that in the eyes of his comrades he bears the accredited accolade of successful endeavor, is enough to satisfy the legitimate ambition of every earnest student of Nature. The real warranty that the march of progress in the future will be as glorious as in the past lies in the perpetual reinforcement of the scientific ranks by recruits animated by such a spirit, and proud to obtain such a reward.

FRENCH INFANT MORTALITY.

M. GASTON LEROUX publishes in the Matin an article on the infant mortality caused by bad and adulterated milk. He quotes statistics of a most painful nature, which would seem to demonstrate beyond doubt that an enormous percentage of the children who die annually in France are literally poisoned by bad milk. This article is illustrated by a map of France, on which the greater or less mortality from that cause is indicated by a small or large black spot. A glance at it shows that France may be divided into two regions, one on the north of the Loire, where more than half the children who die succumb to gastritis, whereas to the south of the Loire not more than one-third die from that disease. At Troyes the percentage of the infants carried off by gastric diseases is 69, at Mans it is 63, at Rennes 64, at Boulonge-sur-Mer 49, at Amiens 62, at Lille 56, at Paris 36. In the south of France the comparatively few deaths of infants from that disease is most striking. At Toulouse it is 31 per cent of the total infantile mortality, at Beziers 12 per cent, and at Clermont only 6 per cent.

Explaining the phenomenon of the high rate of infant mortality from gastritis to the north of the Loire compared to that in the south of France, M. Gaston Leroux says it is due to the adulteration in the north of the country, where the making of butter is a great industry, whereas very little butter is made in the south. He considers that it is, moreover, now completely established that to feed certain children even on unadulterated milk which has been skimmed of all the cream is a dangerous and guilty practice. In connection with the dangers attending the consumption of milk, not only by infants, but by adult persons, it is interesting to note the following lines contained in "Les Principes de Laiterie," written by Dr. Duclaux, Director of the Pasteur Institute:

"Numerous experiments have shown that milk of cows suffering from tuberculosis contains bacilli of tuberculosis, not only when the udder is contaminated with tuberculosis, but when it is in reality healthy and the disease elsewhere. It can be affirmed to-day that numerous persons suffering from tuberculosis owe their disease to milk, and that to avoid the danger of infection, which is much greater than might be supposed, it is necessary to cease drinking unboiled milk."

MAN AS A HEAT ENGINE.

K. SCHREBER.

IF we take the interior temperature at 37 deg. and the exterior as 17 deg. (the average temperature of the air), we find the efficiency would be $100 \times (37-17) \div (37+273) = 6.5$ per cent. Rühlmann gives an estimate up to 24 per cent, but this is vitiated by irregularities of effort which may mount as high as 1 horse power, though the average over a long period is less than 0.1 horse power, and these irregularities do not at once call for similar variations in food. Observations must therefore extend over considerable periods. Rziha gives the datum 127,000 kilog.-meters as a man's mean daily work over such a period. Grasmann gives the heating value of a man's food, per 100 kilogrammes body weight, as 3,400 Ca. during rest, 5,400 during moderate, and 7,600 during hard work. For a man of 60 kilogrammes weight these data would give 6.5 per cent efficiency during hard work. But 60 kilogrammes is too little; say 70 kilogrammes; then the efficiency is 5.6 per cent. Rziha's hardest day's work was 141,000 kilog.-meters. Taking this datum we have for a man 60 kilogrammes weight an efficiency of 6.2 per cent. If instead of 37 deg., as above, we take 39 deg., the temperature of the blood, the 6.5 per cent above is increased to 7.1 per cent. The estimation of the inferior temperature is, however, of more importance, but is difficult; if we take the temperature of the skin (32.3 deg. to 35.8 deg. and 31 deg. on the face), our theoretical efficiency would be only 2.6 per cent. The work of the involuntary muscles may be neglected (the heart 3,000 m. kg. a day). With a theoretical efficiency of only 2.6 per cent, man as a heat-engine would not obey Carnot's law. He should probably be likened not to a heat-engine, but to an electric station with a large accumulator capacity; but it would be difficult, for any short-period test, to ascertain what the reserve of energy was at the beginning and at the end of the test. Still some attempt should be made in that direction.

AN EVIL CONSEQUENCE OF THE "PINCE-NEZ."

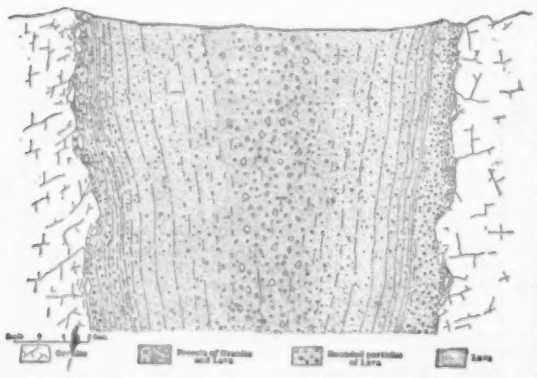
MR. ROBERT D. JOYCE, ophthalmic surgeon to the Richmond Hospital, Dublin, calls attention to a very curious point in regard to the use of "pince-nez," says the Hospital; namely, that in some cases it sets up a flow of tears in consequence of its pressure dragging on the tissues at each side of the nose to such an extent as to pull the lower lid out of position, and prevent it lying properly in contact with the bulbar conjunctiva. In the cases observed the displacement of the lid, with, of course, the inferior punctum, was small in amount, only about 0.2 or 0.3 millimeter. This might easily escape detection, and all the more so, as it has to be looked for while the glasses are on the patient's face. But even this small amount of eversion is amply sufficient to cause epiphora. This, he says, is a very important matter, for such an eversion of the lid, though present at first only when the pince-nez is actually on the face, will become permanent in time, and set going all the troubles associated with ectropion. In a large proportion of cases pince-nez will set well on the face, but in a certain number they are unsuitable, for the above reason, even though they may be a "good fit," so far as the optician is concerned. In some cases it is not possible to fit pince-nez without causing this kind of ectropion, and in such, of course, spectacles must be used.

VOLCANOES.

The late eruption of Mont Pelée has excited a general interest in the subject of volcanoes, and many excellent articles have already appeared in newspapers and magazines on the subject. From the Mines and Minerals standpoint it may be well to consider the subject of volcanoes in their relation to mining. There is a popular idea, deduced from the fact that in searching for the precious metals we have to delve in the bowels of the earth, and from the often observed connection of eruptive rocks and agencies with the occurrence of the precious metals, that a volcano would be just the place where we might hope to find these metals thrown up. We even heard a remark that in the Mont Pelée eruption, quantities of molten gold and silver would be discharged. A mining company conceiving that melted gold and silver might by their great specific gravity after an eruption sink down into the throat of a volcano and there lie in large masses, went so far as to carry out their theory into practice by sinking a shaft in the bottom of the crater of one of the most recent Colorado volcanoes at Dotsero; they found, however, nothing but lava and ashes for their pains.

Although it is an undoubted fact that the precious metals are in their occurrence largely associated with eruptive molten rocks, it is also a curious fact that very little of them is known to be associated with modern crater eruptions, and while sulphur, sal-ammoniac and various gases are obtained from some of the throats of comparatively recent slumbering or extinct volcanoes, we do not remember to have heard of a single mine of importance for the precious metals being operated in the craters or on the flanks of any of our more modern volcanoes. In Colorado the more recent forms of eruptive lavas, such as the basalts which occur so abundantly in dikes and overflows are notably barren, although they have frequently been prospected. We have heard reports that some of these basalts have on assay shown traces of gold and silver, but this can be said of nearly all our eruptive rocks. Nowhere, however, do these modern basaltic rocks have the precious metals in sufficiently concentrated forms to be mined or to be of value. Why this is, we are not prepared to say; we would suggest that as mineral veins are usually found at contact of decomposed eruptive dikes rather than in them, or else in fissure veins in highly altered and decomposed lavas, the freshness of these modern eruptions may not have allowed sufficient time for their fissuring and decomposition and the concentration of the ores out of them into available zones.

In Colorado, with the exceptions of the nepheline

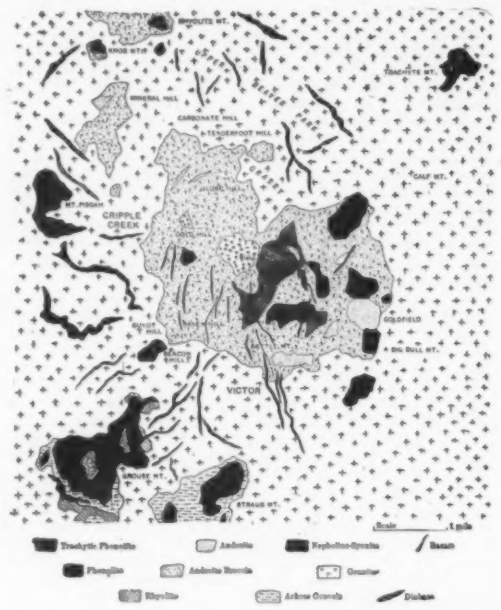


VOLCANIC VENT IN GRANITE, AT VICTOR, CRIPPLE CREEK.

basalts of Cripple Creek closely allied to andesites and phonolites, the basalt family is nearly barren. Other lavas, however, of a different variety and ejected at an earlier period do show evidences of carrying in their composition, or having infused into them, a proportion of the precious metals. Of these are the pyritiferous porphyries of Leadville, and the andesites, diorites and phonolites of Cripple Creek and other regions.

Gold and silver are, however, never found in these lavas in large plates of melted metal. The gold, if found at all, is diffused in and among the crystals forming their composition, or else is concentrated by action of water or heated vapors after the eruption, in veins or veinlets or weak places in or at the side of volcanic masses, and usually involved in the matrix of other and baser ores.

The gold probably did and does come up involved in the volcanic matrix at the time of eruption, but it takes a long series of processes to gradually leach it out of this matrix into veins and other available zones of concentration. This process begins with that phenomena observed after an eruption when the volcanic forces and fires are dying down and expiring, viz., the solfataric period or the period of all kinds of noxious and powerful gases, accompanied by steam and heated waters, hot springs and the like. These may exist for centuries after the eruption and their effects may be studied in almost all our mining camps. Their principal effects may be said generally to be decomposition and alteration of the rocks, leaching out of the precious minerals, and depositing and concentrating them in available forms in crevices and fissures opened by the eruption or by subsequent movements of the rocks. Let us take a few of our Colorado mining camps, notably located in ancient centers of volcanic activity as examples; Cripple Creek is located in the heart of an ancient great volcano or center of volcanic eruption.

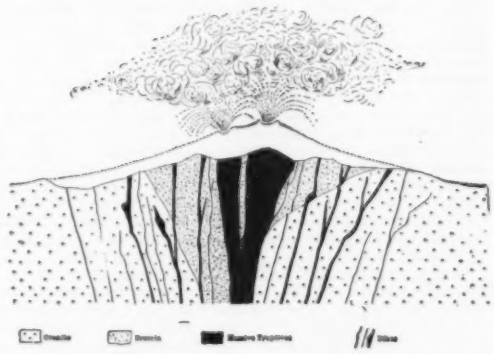


GEOLOGICAL MAP OF CRIPPLE CREEK REGION.

The first eruption was of andesite lava, and doubtless there was a lofty volcanic cone or a number of cones like Vesuvius or Mont Pelée. The eruption took place among the low-lying granitic hills and valleys near the base or southwestern slopes of Pike's Peak. Let us endeavor to follow the probable sequence of events drawn from experience with more modern eruptions of not unsimilar nature.

We may suppose the region was for a long time agitated by earthquake shocks accompanied by terrible subterranean sounds caused by imprisoned steam and formation of steam bubbles and grinding of rocks. The steam was seeking an outlet. Symptoms of the coming eruption might perhaps have been observed in local springs ceasing to flow. As the earthquakes increased in intensity, fissures, small perhaps at first, were opened, and from them ascended hot and acid springs charged with various gases. With increased subterranean activity, the temperature of the springs and gases increased. At last the long imprisoned forces reaching a climax formed a visible fissure or a series of fissures, culminating in a central point or orifice and radiating from it.

From these vents and from the fissures, imprisoned steam and various gases rushed forth with a frightful roar, carrying up, at first, fragments, both large and small, of the granite rocks through which the fissure was opened, and the central throat drilled by the escaping steam. The violence of the explosion reduced much of the rock to an impalpable powder, which, ascending with the steam, formed a dark, ominous cloud, spreading high over the heavens, shutting out the light of day and making an Egyptian darkness over all the surrounding region. By day this appeared as an ominous dark pall, but at night the column of steam was illumined by the glowing interior of the vent and by flashes of vivid lightning caused by the electric disturbance and by the rushing steam and colliding of the uphurled fragments. The under part of the cloud was lurid from the same reflection, while the upper part appeared like a dense volume of black smoke. In a comparatively short time, the fateful cloud of steam with its burden of suspended dust, condensed and descended in awful cloudbursts and torrents of water and mud. This, falling on the mountain, swept down over the surrounding hills and valleys, filling up the ravines and gulches and overwhelming the hills with adobe mud mingled with fragments small and large of granitic rocks which formed the base of the deposits of so-called tuffs and breccias with which Cripple Creek is deluged to a depth in many places of over 1,000 feet. The andesitic lava after this first discharge began to rise up in the vent and well out over the crater edge formed by the fragments of rock that had fallen in the first discharge; and ran in streams down the hill and sealed the flows of adobe breccia. Subsequent explosions followed composed of a mixture of granite fragments, lava and scoria, the latter being the porous, vesicular steam-laden froth floating on the top of the molten lava. A remarkable peculiarity of lava is the amount of imprisoned steam that it holds within its pores so that the lava pours down the hillside more like molten steaming froth than like molten iron, the steam completely obscuring the red-hot mass from which it issues in huge volumes. A lava eruption is a great steam eruption. A crater is a great steam vent. Eruption followed eruption, some explosions filling the air with fragments, steam blocks, scoria, and dust, others of a quieter nature of gentle massive lava flows. In course of time the great activities of the volcano abated, the explosions became less frequent, and the lava retired to its "habitat" within the crater or craters. The explosions and earthquakes had, however, opened a thousand fissures all over the region. The crater itself was doubtless rent in a hundred places by the explosive energies and from all these openings, as well as from the central vent, issued volumes of steam, mingled with all kinds of noxious gases. The solfataric period had now commenced, and the period of mineralization had begun. The gases and vapors issuing from the still heated rocks and fissures were principally steam, but with it were hydrochloric acid, sulphurous acid, hydrofluoric acid and sulphureted hydrogen, and at a later stage, carbonic acid gas and other combustible and noxious gases. Chlorine and fluorine gas took place at the most energetic phases of the eruption. The presence of fluorine gas is shown in the large deposits of purple fluorine, so often found associated with the ores and veins at Cripple Creek. Hydrochloric and other acid gases had the effect of bleaching the rocks and robbing them of their iron constituents, phenomena so often observed at Cripple Creek, especially in the granite of the Independence Mine, which is reduced to a friable cavernous condition by the elimination of its iron-bearing minerals, such as mica and hornblende, their place often being substituted by purple fluorspar and telluride minerals. Direct evidence of hot or acid spring action on the lime elements of the lavas is shown in the Deer Horn Mine, where at a depth of 420 feet a body of gypsum is found associated with fluorine stains and kaolinized rock. Sulphurous vapors and sulphureted hydrogen left these evidences in the iron pyrites with which the rocks near the ore bodies are so fully charged. Hot waters dissolved the silica of the rocks and deposited it in crystals and botryoidal masses of chalcedony in vughs and cavities. On examining the deposits of adobe breccia and tuff, we find evidence of the first explosion



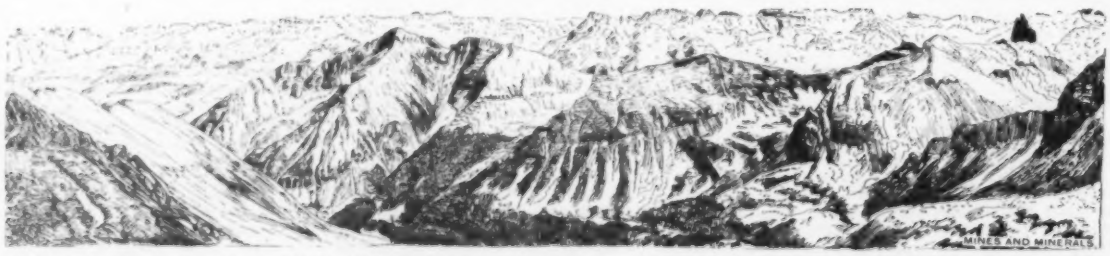
IDEAL SECTION OF CRIPPLE CREEK VOLCANO.

in quantities of fragmental granite as on Straub Mountain, of great massive lava flows as on Battle Mountain, near the Legal Tender Mine, and of subsequent explosive eruptions in a mixture of fragments of granite with those of andesite, the latter gradually predominating.

After the grand eruption there appears to have been a period of temporary rest; the lava having subsided into the crater, cooled gradually, and plugged the throat, as with a massive stopper.

The exact location of the main vent, says Mr. T. A. Rickard, is not as yet precisely known. A miniature vent, however, occurs near the town of Victor in the granitic Squaw Mountain. It is filled with fragments of granite and pellets, nodules, and rounded fragments of andesite lava. In the center the lava forms a red granular matrix, inclosing large pieces of granite. It is a miniature of the greater vent.

In the Rocky Mountains of Colorado we have abun-



CHARACTERISTIC VOLCANIC SCENERY OF THE SAN JUAN REGION NEAR TELLURIDE, COLORADO.

dant evidence of past eruptions and of volcanic agencies and activities. Our granite mountains are girded together by dikes of lava, called, by the miners, "porphyry." Our largest and richest deposits of ores are found at the contact of these dikes and intrusive sheets with other rocks, as at Georgetown, Central, Boulder, Leadville and Aspen. Cripple Creek is located on the top and in the heart of a ruined center of eruption which doubtless had its crater or craters long since eroded away. The Cripple Creek volcano must

have formed a conspicuous and steep mountain as is commonly the case with volcanic cones, built up of comminuted material from a highly explosive crater. The volcano had several vents, as evidenced by solid plugs of massive lava at different points, such as at Hull Placer, Anaconda, the Lilly and Vindicator mines, and the patch of syenite porphyry between Gold Hill and Squaw Gulch.

The period of comparative rest and quiet occupied by the solfataric reign and the filling of all available openings and fissures with vein matter and ore-bearing minerals, was broken by a second disturbance, this time of phonolite lava. The second eruption, finding the original vents firmly plugged and sealed with andesite lava, found relief by opening fissures all over the region, both in the outlying granite districts as well as among the tuffs and breccias around the main focus of eruption. The eruption of the phonolite and the succeeding nepheline basalt appears to have been more of a fissure than crateriform eruption, hence the appearance of the phonolite on the surface is in the form of dikes and intrusive sheets. No surface lava flows of phonolite or phonolite scoria have been as yet observed. The period succeeding the phonolite and nepheline basalt eruptions seems to have been one of great mineralization, for we find both phonolite and basaltic dikes heavily charged with tellurides and other gold-bearing ores.

After these eruptions the volcanic forces seem to have abandoned the vicinity and transferred their activities to the districts further north, which are heavily covered with andesitic and basaltic lavas.

About the same time the neighboring district of Rosita, some twenty miles south, was in a state of eruption with a sequence of alternate explosion and quiet, or massive eruptions, followed by a solfataric period and its attendant mineralizing influences. The vent of one of these eruptions is found in the circular throat of the Bassick Mine, filled with an agglomerate of volcanic and other pebbles compacted in many cases with a cement carrying very rich minerals.

The San Juan region, covered with enormous flows of lava and volcanic breccia, is probably an example of fissure as well as of explosive eruptions, in the vicinity of a lake, occurring during the same Tertiary period. Profound and wide fissures were opened in the cooling lava, either by contraction of the lava or other causes, and these were gradually filled by quartz and vein and mineral matter by ascending hot springs.

The huge mountains of volcanic breccia look to-day much as the mud flows of Martinique will appear some years hence when they have settled down, hardened, and consolidated into rock. Near the San Juan is the Elk Mountain region with its peculiar laccolitic volcanic mountains of another and more ancient type of eruption which would not at the surface have shown such a frightful display as did Mont Pelée, but might, when they were in process, have produced very great earthquakes. The Elk Mountain region was a laccolitic subterranean eruption of great bodies of lava that did not come to the surface, but congealed in huge masses beneath it. The earlier eruptions of the porphyries of Leadville were of the same intrusive character. In all cases since the first eruption took place vast erosion has followed. Lofty volcanic cones that may, as in the case of Cripple Creek, have towered above the surrounding country, have been washed away and scattered, and the very foundations and ground plan of the volcano exposed. Vast overlying sheets and thicknesses of lava, as in the San Juan region, have been eroded off and yet have not been bitten down into the underlying granite deep enough to reveal the dikes or fissures from which the lava issued. In other places, as the Elk Mountain region, erosion has progressed so far as actually to unearth the buried masses or reservoirs of lava and place them on top of the eroded plain as a lofty group of mountains.

At Leadville and Aspen, erosion has so far removed overlying sedimentary rocks as to display the buried intrusive sheets and the feeding dikes even down into the granite. Erosion has thus shown us the anatomy of the wonderful volcanic eruptions, and also laid bare for the miner the stores of wealth they contain.

We walk or ride along over vast beds of lava, volcanic breccia and tuff, we dig down after the precious metals in the bowels of extinct volcanoes, and picnic, maybe, in an old crater or on its ruins, and think little of the awful scenes these once displayed, scenes probably comparable with those of the Mont Pelée catastrophe, but without its accompanying destruction of human life.

Craters and very recent-looking lava fields occur near Albuquerque; and along the side of the railway track of the Santa Fé on its way to the west coast we see modern gulches and old river beds filled with ropy looking coils of lava, which from its freshness and from the absence of vegetation over it, appears as if it was poured out only a year ago. These lava flows are traceable up to equally recent-looking craters, one of which, near Park View, is filled by a lake. These give the geologist, as well as the casual observer, the impression that their date of eruption might be placed within the hundreds rather than thousands of years past, and within the modern era.

Scattered over the mountain and park region of Colorado, we have a few well-defined craters still remaining. The most recent-looking and best preserved, with its accompanying lava flow, is that at Dotsero, a little station on the Rio Grande Railway between Leadville and Glenwood Springs, near the junction of the Eagle and Grand rivers.

That an eruption of this extinct volcano occurred within the human period, and possibly even within the memory of some Indian tribe is evidenced by the fact that it covers the present river meadow, and that vegetation has gained scarcely any foothold on the black cindery mass, which looks as fresh as if it had been erupted but a few weeks ago. At present the volcano shows as little signs of life as did Pelée or Vesuvius before their outbreaks.

Whether or not this apparently extinct volcano will again become active cannot be presaged. Most of these seemingly modern craters, be it observed, are located in such out-of-the way districts that if they did again erupt they could do very little harm.—Mines and Minerals.

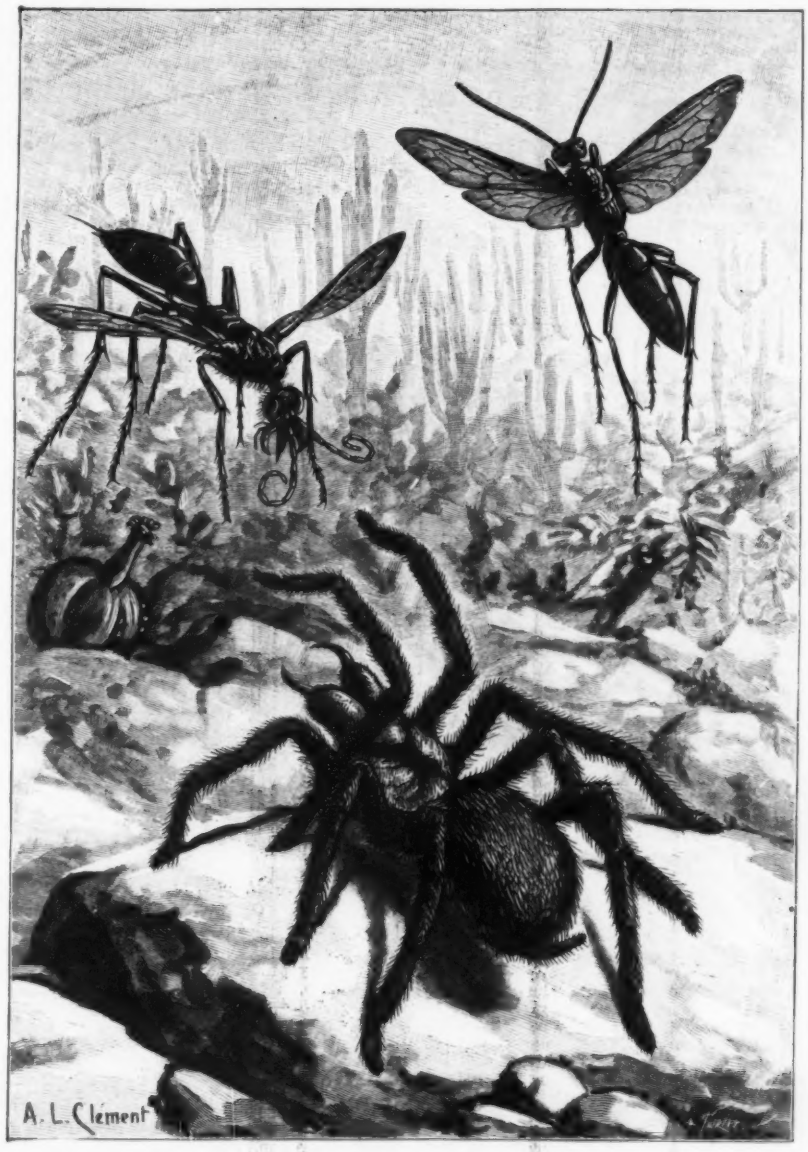
THE SPIDER-HUNTERS.

THE hymenopterous suborder Pompilidæ, of which about seven hundred species are known, has a wide geographical range, from the temperate zones to the tropics. Although the insects belonging to it are the ordinary prey of spiders, certain species boldly attack their enemy, and, after paralyzing it with their formidable sting, store it in their nests as food for their larvæ. Other species, again, reduce the spider to a state of immobility by amputating its eight legs. The object of this is perhaps to render their prey more transportable by the removal of parts that are not only cumbersome, but useless as food.

The insects shown in the accompanying engraving, from La Nature, are displayed in a glass case in the gallery of applied entomology in the Museum of Natural History of Paris. The wasps and spider are mounted upon a sheet of cardboard, at the top of which may be read the words "California Curiosities." The ticket pasted upon the case reads: "*Eurypelma Hentzii*, with which the *Pepsis ornata* stores its nest; North America." In the interior of the case there is a sheet of paper which gives the information that the insects were brought from the Chicago Exposition by Dr. Pozzi and given to the museum by Dr. Laboulbene. Darwin, who made some observations upon analogous species in the vicinity of Rio de Janeiro, shows us the wasp (a *Pepsis*) attacking its prey (a *Lycosa*), and then immediately flying away. The spider, in trying to escape, rolls over upon the ground and has just enough strength to allow it to conceal itself in a tuft of grass. The wasp, having returned, discovers it after a little search, and, cautiously approaching it, stings it twice in the lower side of the thorax. Facts of the same kind are to be daily witnessed in our own country. Lepelletier mentions the case of the *Tegenaria*, which rushes from its lair upon the wasp that shakes its web, and stops in front of it startled and unable to advance or recede; whereupon the wasp makes for it and pierces it with its sting, the poison of which paralyzes it immediately. The species of Pompilus, in fact, that are frequently seen along roads and declivities in the country, running with vibrating wings and tremulous antennæ, and always flying with a busy air, feed their larvæ upon spiders, and never allow the menacing fangs of the latter to intimidate them. It is, says Fabricius, the "paralyzer" and the "killer" face to face—one armed with powerful fangs and the other with a poisonous sting. Although they have not the terrifying aspect of the immense exotic species, our indigenous spider-killers have been more attentively studied and their habits are better known.

The annulate Pompilus (*Calicurgus annulatus*) attacks the tarantula (*Lycosa tarantula*), the bite of which, dangerous even to man, quickly kills a bird, and introduces it in a paralyzed state into a nest in the form of a hole closed with rubbish, after having fixed its egg near the base of the abdomen. The spider, which presents no visible lesion, and the extremity of the legs of which alone exhibit any motion, is thus preserved fresh for about seven weeks.

Another Pompilus (*Pompilus apicalis*) attacks the species of *Segestria*, although smaller than they. Held by a silken thread, the spider rushes upon the wasp, which avoids it and attacks the spider in turn, while the latter is returning to the entrance of its lair, and continues the assault until it has succeeded in causing the enemy to fall to the ground. Here, says Fabricius, the spider gathers up its legs and endeavors to conceal itself in some cavity or other; but, soon rejoined by its adversary, it is immediately stung. The wasp then begins an exploration in the vicinity, walking with ease over webs and feeling with its antennæ the tubes inhabited by the spider. After it has found an empty one to suit its convenience, it returns for its victim, drags it backward to the web, and, after inserting an egg in its body, introduces it into the tube and then closes the latter with some sort of debris. Here, upon the silken tissue of the spider's nest, the larva of the wasp develops and feeds upon the victim at its ease.



THE TARANTULA-HAWK.

(Eurypelma Hentzii.)

Other wasps, such as the *Pompilus octopus*, form burrows and feed their larvæ upon spiders of the genus *Epeira*, which they capture in their web, over which they nimbly run without ever getting entangled therein, as happens with all other insects.

The Pelopæi also feed their larvæ upon spiders in the cells of a nest constructed of a masonry of mud, which hardens in drying. Each cell, according to its size, contains a variable number of spiders, sometimes as many as twelve.

At Temate, M. Maurice Maindron made observations upon the *Pelopæus latus*, which constructs its nests of mud under sheds, and even against the walls of dwellings, where it is tolerated by the inhabitants because it hunts and destroys the spiders that stretch their webs in the rooms. But M. Maindron justly observes that these webs capture large numbers of the mosquitoes with which the country is infested, and consequently the spiders render genuine services. As in the case of the Pompilus, the spider seized by the Pelopæus is immediately paralyzed by the latter's sting.

The Agleniæ construct mud nests resembling little pots smaller than a cherry-pit, each glazed within and containing a small spider with an egg upon the side.

The history of the spider-hunters is not yet completely known, especially as regards the manner in which they operate upon their victims, and that, too,

despite the valuable observations of Fabricius; but, such as we have it, it is worthy of being related.

A NEW TELEPHONE RELAY.

A NOVEL method of reinforcing telephone currents forms the subjects of two patents recently granted in the United States to Mr. Joseph Lyons. The invention is based on that of Hutin and Leblanc of a machine for reinforcing alternating currents by causing them to reproduce an alternating field within which are rotated closed circuits at a rate exceeding a certain critical speed.

The reinforcing of the faint telephone current is accomplished by reducing the apparent resistance of the line to those currents continuously and practically to any desired extent. The telephone currents are primarily caused to produce an alternating field or fields of force varying in frequency and intensity with the frequency and the variations of intensity of the telephone currents, and within such field or fields there are rotated electric circuits closed upon themselves, with a speed that exceeds a certain critical speed. By the rotation of these circuits within the initial magnetic field or fields the electro-magnetic reactance of the telephone circuit is reduced, whereby the initial field or fields and the exciting currents are reinforced.

Machines for reinforcing faint alternating currents of one definite frequency by causing them to produce an alternating magnetic field or fields and rotating within the latter circuits closed upon themselves with a speed exceeding a certain critical speed, have been suggested for use as constant potential alternating current generators. The machines of Hutin and Leblanc are of this type, but they have been used only for the reinforcement of an alternating current of one definite frequency; and the speed given to the closed circuits was calculated and determined with reference to the frequency of the single current led to and reinforced by the machine.

The rule which governs the operations of such machines is that if the frequency of the alternating current led to the machine is designated by $\frac{1}{T}$ and if the number of poles of the field excited by these currents is designated by $2n$, then in order that the initial field and the initial current be reinforced, the number of revolutions of the circuits closed upon themselves must exceed the quantity $\frac{1}{n\,T}$. This rule may also be stated in these words: The number of rotations of the rotor must exceed the frequency of alternations of the alternating current that excites the stator divided by half the number of poles of the latter. My invention is based upon the utilization of the principle embodied in these reinforcing generators for the reinforcement of multiperiodic varying currents—that is to say, the reinforcement of telephone currents.

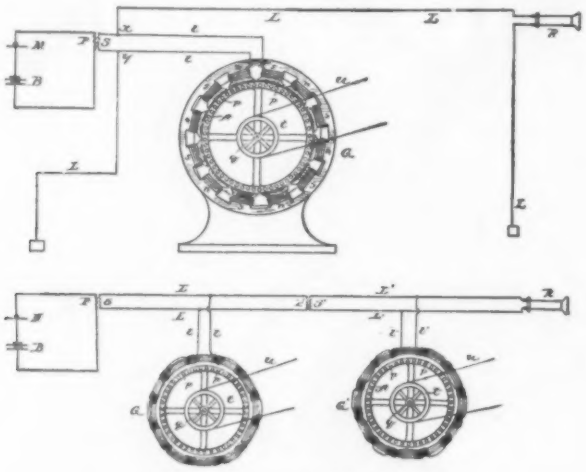
In telephone practice, alternating currents of constantly varying periodicities and intensities are generated. It has been found that the currents corresponding to the highest pitch of sounds uttered against the telephone transmitter rarely exceed the frequency of 800 per second. All other frequencies that occur in practice are below 800 per second. In order to reinforce alternating currents of the frequency of 800 with a machine of the Hutin-Leblanc type, having let us say, twelve field poles, the circuits closed upon themselves have to be rotated at a speed exceeding 133 revolutions per second. If this be done, then not only the currents having a frequency of 800 will be reinforced, but all other currents of a lower frequency will also be reinforced. Upon this principle Mr. Lyons' invention is based.

Mr. Lyons accordingly passes the faint telephone currents at any point on the line through the field-coils of a machine of the Hutin-Leblanc type, and rotates the armature of the machine with a speed exceeding the number of periods of the highest frequency current that occurs or is likely to occur in telephony, divided by half the number of poles of the field magnet. By this process the lower frequency currents are more reinforced than the higher frequency currents; but this does not vitiate the reproduction of speech, but on the contrary improves it, since lower frequency vibrations must be of higher amplitude than those of higher frequency in order to produce sounds of the same intensity as the latter.

The accompanying illustrations represent the invention applied to an unbroken line, and to a line divided into sections. *M* is the transmitter, *B* the battery, and *PS* the induction coil of the usual telephone circuit. Wires, *l l*, tapping the line *x* and *y*, complete the circuit of the field coils of a Hutin-Leblanc reinforcing alternating current generator, *G*. The generator, *G*, is composed of a stationary field-ring provided with inwardly projecting radial pole-pieces, *n s*, which are wound alternately reversed and are shown connected in series, so that a current which produces in one pole-piece a north pole, will produce in the next succeeding and in the next preceding pole-piece a south pole, as indicated by the letters, *n s*, in the upper drawing. The rotor of the reinforcer comprises ordinarily an iron ring faced on each side with a flat annulus, *A*, of copper. The iron ring, as well as the two copper rings, are pierced, so as to receive copper pins, *p*, riveted at each end to the copper rings. The copper rings, *A A*, together with the rings, *p*, form a large number of electrical circuits of low resistance closed upon themselves. The system thus produced is secured upon a spider, and the whole mounted upon a shaft, *q*, driven by a pulley, *t*, and a belt, *u*.

The lower diagram shows the main line divided into parts, *L L* and *L' L'*, connected by the induction coil, *P' S'*. In each branch there is a reinforcing machine, *G G'*. By reason of this division into sections, small reinforcing machines can be used on comparatively long sections of lines, so that speech can be transmitted over very long distances.

When the transmitter, *M*, is spoken into, alternating currents are generated in the secondary, *s*, of the induction coil. One branch of these currents passes into field coils of the reinforcing machine, *l l*, and another passes to the line, *L L*. Both current branches are exceedingly weak. The branch passing to the line is too weak to cause an audible reproduction of sounds in the receiver, *R*, if the line exceeds a certain length; but if the rotor of the reinforcing machine be driven with such speed that its number of rotations per second exceeds the number of periods of the current due to the sound of highest pitch is spoken into the transmitter divided by half the number of poles of the field, then the initial and exceeding weak alternating field excited by the telephone currents is reinforced, and those currents themselves are reinforced. It is claimed that this reinforcement of telephone currents can be carried practically to any extent.



A NEW TELEPHONE RELAY.

PERSONAL NARRATIVE BY CAPT. SVERDRUP OF HIS ARCTIC TRIP.

WE give below a narrative, transmitted to the London Times telegraphically by Capt. Otto Sverdrup, of the four years' work of the expedition in Dr. Nansen's ship, the "Fram," of which he was the commander. The expedition, it will be remembered, left Christiania in June, 1898, its principal geographical object being to ascertain the extension of Greenland toward the north, to determine the yet unknown configuration of the mainland, and, if possible, to discover whether this great Arctic land finally breaks up into groups of islands in the north. It was also understood that, if circumstances were favorable, Capt. Sverdrup, like Lieut. Peary, would make an attempt to reach the North Pole. The "Fram" underwent considerable modifications and improvements, and was in every way fitted to battle with the difficulties that were sure to be encountered. It was hoped that the expedition would ultimately round the north coast of Greenland, and come out at Cape Bismarck, the most northly known point, the "Fram" meantime being sent back round Cape Farewell to meet the party. The expedition consisted of 16 men, six of whom were men of scientific training; geology, botany, and zoology being all represented by specialists. Astronomical, magnetic, and other physical observations were all provided for, while an officer was to attend to cartographical work. The surgeon, who unfortunately died early in the course of the expedition, was to take charge of meteorology. In short, every department of scientific work was provided for. The principal members of the expedition, besides Capt. Sverdrup, were Lieut. Isaachsen, Mr. Bay, zoologist, Mr. Simmons, botanist, Mr. Schei, geologist, Mr. Svendsen, surgeon. All on board were prepared to put their hands to work of all kinds. A good supply of dogs was taken on board, and every preparation made for sledge expeditions. The Greenland settlements were reached about the end of July, and an attempt was made to push the "Fram" northwards through Robesa Channel, but she was caught in the ice at Cape Sabine, off Ellesmere Land, about 79 deg. N. lat. And here Capt. Sverdrup's narrative begins.

On August 17, 1898, we were stopped a little north of Cape Sabine by masses of ice, which we could not penetrate. The cold immediately set in and the new ice rapidly increased. We were, therefore, compelled to take up our winter quarters at Rice Strait. In the course of the autumn we made a sledge journey on the inland ice of Ellesmere Land. Exploring and mapping the innermost part of the fjord at Hayes Sound was commenced. In addition thereto we made hunting expeditions, chiefly to procure food for the dogs. We shot about 25 walruses and 11 musk oxen. With such a large increase in the dogs' food I saw no objection to wintering at this place. Here was a good and large field of work. In the course of the winter a hut was built, which we intended to put up on Robeson's Channel or further north. I proposed at that place to land a well-equipped sledge expedition consisting of Bay, Isaachsen, Fosheim, and myself, and let the "Fram" return to Melville Bay or Baffin's Land the same autumn. We would then have wintered in the hut, and the next spring journeyed round the north coast of Greenland down to Sabine Island, on the east coast, and here be met by the "Fram" the same autumn. We were, therefore, very busy during the whole winter with the preparations for the sledge expedition. During the spring of 1899 two sledge journeys were made across Ellesmere Land to the west coast, the one across the glacier district, the other further north, across country free from ice. The mapping at Hayes Sound was completed. Scientific investigations were carried on until we left our winter quarters. The summer of 1899, which we had hopefully looked forward to, turned out unfavorable. An attempt to pentrate Kane Basin appeared to result in getting stuck in the ice. Our food for the dogs would then, in the course of the winter, have been exhausted, there being little or no opportunity here for catching anything. I therefore decided to go to Jones Sound, in consequence of which we left Smith's Sound August 22, 1899. On the way we caught such a number of walruses that we had sufficient food for the dogs to last them through the winter. We took up winter quarters on the south side of Ellesmere Land, in lat. 76 deg. 29 min. north, and long. 84 deg. 24 min. west. Shortly afterward I made a boating excursion with three men to explore and lay down a depot. We were, however, shut up by the ice and were compelled to remain one month near the boat before we were able to go on board. On the ice on the return journey we met Baumann and three men, who had gone out in search of us. We learned from them the sad news that Braskerud had died after some days of illness. He had caught a cold while out hunting. After the arrival on board we made preparations to start for mapping and for laying down depots. October 22 we were stopped by open water, 68 miles from the vessel; the fog was lying so heavy and thick westward that we could form no decided opinion as to the extent of the open water. The portion of the coast which we had passed ran, to our surprise, in a true westerly direction, which we could see was the case further on. According to Inglefield's map, the country ought to have curved northward. From our winter quarters we laid down the depot, and then entered a large fjord east of the depot, where we shot 26 musk oxen. On November 16 the journeys were finished for the autumn.

When all the meat and the furs were on board, preparations for the long sledge expeditions the following spring commenced to occupy all of us. On February 23, 1900, Isaachsen, Schei, Stoltz and Bay proceeded with four packs of dogs to the depot in order to examine it and lay down some more provisions. They returned on March 3 with the information that there had been some heavy ice-scrapings at Jones Sound, which impeded the advance of the vessel. The depot was also destroyed by bears and almost all the dogs' food eaten up. In a westerly direction they had seen much watery sky. This news caused us to manufacture quickly a canvas tent, and on March 7 Bay, Fosheim and myself again set out on fresh explorations. Bay was left behind at the depot on watch, while Fosheim and myself proceeded westward. Already the same day we left Björneborg, which was the name we gave the depot, we met with open water, where large floes of ice were drifting backward and forward in the rapid current in the sound between North Kent and Ellesmere Land. The advance along the sound proved very difficult. We returned and came on board on March 14. The main expedition started in two parties with nine men and dogs on March 17 and 20. From Björneborg all proceeded on the 23d, reaching the sound the following day. The passage along the sound proved very difficult on the rugged ice. In many places there were pressure ridges right up to the side of the mountain. These pressure ridges at several places had to be worked through with pick axes, mattocks, and spades. At other places the ice would be quite smooth, so that we, at steep inclines, ran the risk of losing both loads and dogs in the sea. After having traveled for three days, we passed the sound, which is 20 miles broad, without other mishap than losing a load in the sea. The rope connecting the dog with the sledge, however, parted; so that the dog was saved from following the sledge. Northward we met with fairly smooth ice. The 31st of March, 175 miles from the vessel, the returning party, consisting of Baumann, Raanäs, Schei, Stoltz and Henriksen turned back to Björneborg. At that period we experienced a temperature of 42.5 deg. of frost, and great difficulty in advancing. Two sledge parties proceeded further northward for exploring the unknown west coast of Ellesmere Land, each with provisions for 50 days. The one party consisted of Isaachsen and Hassel, and the other of Fosheim and myself. North of the sound, between Ellesmere and North Kent, a large bay extends eastward about 100 miles broad. On the northern side of the same some large complicated fjords are situated. The land extends about 50 miles westward from these, after which it runs in a north and northwesterly direction. In lat. 79 deg. Isaachsen and I parted, Isaachsen receiving instructions to explore some new land which we sighted to the west of us. After he had been there he was to try to explore the coast back toward the south coast. I continued myself further northward along the coast. We parted on April 16. The land which Fosheim and I traveled through is very hilly and intersected by large fjords, of which several are from 15 to 20 miles broad at the mouth. On May 4 we reached lat. 81 deg. north. From here the land

extends in a northerly direction. We returned to Björneborg on June 2.

During the whole time we experienced uncommonly severe weather, and what especially impeded the work was fog and thick weather almost the whole time. No game was seen on the stretch of coast covered, in consequence of which the dogs suffered much from insufficient food and the inclement weather. Bay had after our departure an encounter with a ferocious bear, which he at last killed. Fosheim and I came on board on June 4, after an absence of 76 days. During the whole journey we experienced almost daily snowstorms, accompanied with severe cold, when the snow and ice rendered it most difficult to proceed. Isaachsen and Hassel came on board on June 19, after having been 90 days absent. After having reached the new land in long. 98 deg. west they turned back according to agreement, to the place where they separated, whereupon they traveled southward and afterward eastward to about long. 89 deg. west. Here they discovered a large system of fjords, proceeding up some of them. As it commenced to get on for the summer before we separated I had pointed out that we, of course, might try to reach the south coast about May 20. Owing to the open water, and as the provisions began to run rather short, they were compelled to turn in about lat. 79 deg. north. They had, however, plenty of meat, killing a total of 12 musk oxen. The blubber of bear formed a substitute for fuel as the paraffin became exhausted. At the place where they turned the land was very low, converging northward on both sides. A pressure ridge could be seen in the hazy atmosphere to extend at some distance right across the fairway. These facts gave us the firm belief that this would be the bottom of the fjord. The time, however, did not allow them to investigate this right down to the bottom.

A third party, consisting of Schei and Henriksen, with provisions for 40 days, chiefly on geological investigations, came on board on June 1. They had traversed two islands situated north of the sound and been some distance into that fjord, where Isaachsen and Hassel were. On the return journey they traveled across a large peninsula southeast of the fjord. Baumann was in command of the returning party. After they had left us they experienced very stormy and cold weather, and several were frostbitten in the face and on the hands on their arrival at Björneborg. From there they had accompanied Schei to the north point of North Kent, after which they went on board. On their return journey they met with a heavy gale, which smashed the tent-poles and tore the tent to pieces. In May Baumann with his party made some investigations in order to find a passage overland whereby the sound might be avoided. We knew, of course, that it would be impossible to pass on our return. He deposited information at the agreed place north of the sound. On the return journey they took the boat on board which they had left behind in the autumn. On my return to the "Fram" I learnt the horrible news that the vessel was nearly destroyed by fire on one of the last days of May. The awning had been ignited by a spark from the funnel and was soon entirely enveloped in flames. The kayaks stored under it, as well as other inflammable things, burned violently. An iron tank, containing about 200 liters spirit, stood in the middle of the fire. The main rigging and the mast caught fire. Fortunately, it occurred in the middle of the day, while there were plenty of people about on the deck. Along the side of the vessel we had water enough for extinguishing the fire. We succeeded in subduing it, but the "Fram," I am sure, has never before been nearer her destruction. Twenty skins of musk oxen and some bearskins were destroyed by the fire.

The summer work commenced with scrapings, at first through cracks in the ice, afterward at various places. Gradually the ice broke up. Here were still many and great problems that were waiting to be solved before we could leave the vessel this summer. The 9th of August we steamed out from our winter quarters, steering westward along Jones Sound. We got on the 16th fast in the ice north of Grinnell Island. A heavy northerly breeze kept the ice tightly together. We remained lying here till September 16, when the southerly gales dispersed the ice. We then proceeded down through Cardigan Strait and took up our winter quarters in the fjord next to the sound, lat. 76 deg. 48 min. north and long. 89 deg. west of Greenwich. We shot this autumn 28 musk oxen, and, as last autumn, a number of hares. The flesh of the oxen was lying at the north side of the sound until we got more snow, guarded by Baumann and Raanäs. The passage we now used to the coast northward went across a neck of land about 600 feet high. The place where we got down to the sea we called Nordstrand. After the autumn hunting was completed Olsen and I were to proceed up to the large fjords north. The first day we pitched our tent at Nordstrand. Next day Baumann went on board to fetch some provisions, and an hour afterward Olsen and I continued northward, the sky south having the appearance of bad weather. I did not want to go north across the bay, but turned on the new ice toward land to proceed along this. As the storm commenced with full violence I thought it would very soon go down, but, on the contrary, it continually increased. Olsen fell and got his arm out of joint at the shoulder. As the wind was too strong for a traveling tent to be pitched, we had to go back to Nordstrand, which we were fortunate enough to reach in some hours. I succeeded in placing Olsen in a tent, but my attempts to set the arm right were in vain. The storm lasted for three days. Two of my best dogs were choked by the snow, and one I lost on the hunting expedition last autumn. The fourth day we proceeded on board and put Olsen's arm right again. Baumann had come on board successfully. Schei and Isaachsen, who were out hunting at that time in Jones Sound, lost four dogs.

The men were now conveyed on board, and by this the winter work was again resumed, consisting in preparations for the coming season. During the winter we were much visited by wolves. We had enjoyable wolf hunts during the silent hours of the night. We captured a few alive, which we are bringing with us. The winter was uncommonly stormy and cold.

On March 12, 1901, two parties went out, each consisting of four men, to lay down depots. Isaachsen was to explore the lands discovered in the west, and I to try to find the sound which we thought would separate Ellesmere Land from that land where I traveled last year. There was a system of fjords east of this route, which had not yet been explored. It was, therefore, natural to investigate this tract of land. If the sound were not there it would necessarily be continued where Isaachsen turned back last year. The weather during these depot journeys proved very boisterous. During the fourteen days we were out the mean temperature was minus 45 deg. C.; some days it was even below minus 50 deg. The 8th of April all parties set out, Isaachsen and Hassel westward, Fosheim, Raanäs, Schei and myself northward, Baumann and Henriksen accompanying us a little distance north of the depot. Thereupon we proceeded further northward, but found ourselves now at the bottom of this system of fjords. When we could find no reasonable land passages we turned back and entered a fjord immediately north of this system. On April 26 we reached the bottom of this fjord. Here we found a fairly good passage northward, where we got down to the sea on April 29. This was that system of fjords which, as stated above, had been traversed by two parties last year. On May 1 we saw from lat. 79 deg. north, in very clear weather, that there was still some sea ice outside the sound. We continued northward. On May 4 I dispatched Fosheim and Raanäs across to follow the eastern land, whereas Schei and I continued along the western. At lat. 80 deg. 30 min. north the land turned westward; on the west side of the sound we followed the latter, but found ourselves very soon in rough polar ice. As the weather now commenced to be very stormy and foggy, we had to turn, sacrificing the rest of the season, to the piece traversed and southward from where not a few fjords are running into the land. On May 17 we were roused at night by an awful howling from the dogs. When we came on deck we found twelve wolves which were on the point of carrying away one dog of my pack. When we commenced to fire at them—and some of the wolves were killed—the rest ran away rapidly. Three remained on the spot, while two had a narrow escape. The dogs were quite helpless, as they had muzzles on. On June 18 we arrived at the "Fram." Isaachsen and Haslund found, in about lat. 78 deg. north, a sound separating North Cornwall from the track of land situated to the north. We traveled through this sound, following the south coast of the land, north of North Cornwall westward and then northward. Then we continued along the land in a northwesterly direction, lat. 79 deg. 30 min. north, and long. 106 deg. west, when the land turned eastward and southward. On the west coast no land could be seen westward and on the northern coast nothing to the north either; only rough polar ice in these directions.

As a contrast to Ellesmere Land, these tracts of land are rather low, the highest not reaching over 1,000 feet. Bears were shot on the south coast; reindeer could be seen, and appeared to be plentiful. Isaachsen then went southward and eastward. These islands were, in this manner, explored all round, after which Isaachsen traveled down on Graham Islands, and across to Ellesmere Land; he came on board on June 7.

Baumann and Stoltz left the "Fram" on April 24 in order to investigate more closely the system of fjords, into which I first entered this spring. It was proved on this trip, what we had also found earlier in the spring, that the neighborhood round these fjords is probably those parts of Ellesmere Land most abounding in game. Musk oxen, reindeer and wolves are very plentiful. Fosheim and Raanäs had explored a fjord about 70 miles long which runs in from Greely Fjord in a southeasterly direction. They had also had an encounter with wolves. Fosheim shot three of them. They returned along the east side of the land and came on board June 13, partly for the purpose of mapping and partly for scraping. Simmons, Isaachsen, Bay and Henriksen remained out in the open water in Jones Sound from June 24 to July 19. Thereafter Isaachsen, Schei, Stoltz and I made a boating excursion in order to explore the land of North Devon, south of our winter quarters. We came on board on August 7.

The whole of this summer appeared very unfavorable for getting out of the ice. On the other hand, we did not quite believe that we were to be shut in either. When, toward the end of August, there was still ice of three feet thickness and the frosty weather threatened soon to commence, we came to the conclusion that we should remain here one year more. We tried with blasting, etc., but to no purpose. Then we tried to force a passage along the land at every high water, as the ice there would always be somewhat slack. In this way we succeeded in advancing nine miles southward, but after having touched the ground several times we did not get out. We now had to procure food for the dogs during the winter. Two hunting parties in Jones Sound got about twenty walruses, which proved quite sufficient. Bay remained on guard at the meat, until the ice became thick enough for it to be conveyed on board. On a very dark night in October he was surprised by a bear. He tried to get out, but his sweater caught something in the door, so he could not move. However, he fired his rifle. When it commenced to dawn he crept out and found the bear lying dead not far away. After the walrus hunting, two parties were dispatched northward to procure fresh meat for the winter—the one Isaachsen and Schei, the other Fosheim and Raanäs. The former shot about eighteen musk oxen, which were transported on board; then the walruses were brought on board, and the excursions were at an end—November 4, 1901.

The winter was spent in preparations for the coming spring. On April 2 I and Schei traveled northward, accompanied by Baumann and Raanäs part of the way. The object was to get connection with Lieut. Aldrich's point at Grinnell Land, part of which was still unexplored. We turned back on May 9 in lat. 81 deg. 37 min. north, and came on board on June 16. Isaachsen, Fosheim and Hassel deposited information concerning the expedition in case of a relief expedition at six places on the south coast of Ellesmere Land from April 1 to April 18. Isaachsen and Bay explored the north coast of North Devon from April 23 to May 22, whereupon Isaachsen and Simmons made a twenty-four days' sledge excursion in order to fetch fossils from a fjord in the north, where they had formerly discovered considerable beds of coal. Baumann, Raanäs and Fosheim made, this spring, a sledge excursion to Beechey Island in order to fetch several things we were in want of from the English depot. The depot was, however, destroyed, and only some part of the house remained standing. The cutter "Mary" had been rendered unserviceable; the mast sawn off as well as the deck beams.

The summer of 1902 has been employed in various work. Simmons, Bay, Isaachsen and Henriksen were out with a boat in Jones Sound to scrape, take observations, etc., from July 7 till August 5. When they had got to a small island at the mouth of Norfolk Inlet, a southeasterly gale began to blow, which forced all the ice up into Jones Sound. As the wind continued to blow, the ice became so packed at certain times of the day that one could walk on it. Provisions began to run short, as they were only fitted out for a 14 days' trip. After the ice had kept them on the island for ten days and the state of things had somewhat improved, they had to make an attempt to enter through, no matter what it would cost. They succeeded, but four or five times the same attempt had to be made at other places, with the greatest probability of the boat's being smashed or drifting out to sea with the ice, which was whirled round in the violent current. At last when there was only a minimum of food left, they had to abandon the boat. They then went to the mouth of the fjord in which the "Fram" was now lying, but at the eastern side, while they were on the western; the next day we saw them and fetched them to the "Fram." On August 6 we started from this fjord, and fetched the boat left behind; whereupon we proceeded out of Jones Sound. We arrived at Godhavn, Greenland, on August 18. We left there on August 22, passed Cape Farewell on August 28. Since that time we have almost exclusively used the sails.

OTTO SVERDRUP, Commander of the "Fram."

[Continued from SUPPLEMENT No. 1397, page 22396.]

SELECTED FORMULÆ.

Toilet Preparations.—

Violet Water.

Tincture of vanilla	17	ounces
Tincture of orris root	4½	pints
Rose water	7	pints
Oil of sandal	3	ounces
Oil of rose geranium	5	ounces
Oil of bergamot	10	ounces
Oil of wintergreen	160	minims
Spirit of ionone	2	ounces
Deodorized alcohol	9	pints

Vanilla tincture, which is sometimes objectionable as to color, may be replaced, if desired, by an alcoholic solution of artificial vanilin, the strength being 1 ounce to the gallon. The spirit of ionone is a solution of 1 part of the substance in 20 parts of deodorized alcohol.

Toilet powder in some variety may be made by the appended formulas:

Violet Poudre de Riz.

I.

Corn starch	7	pounds
Rice flour	1	pound
Powdered talc	1	pound
Powdered orris root	1	pound
Extract of cassie	3	ounces
Extract of jasmine	1	ounce

II.

(Cheaper.)

Potato starch	8	pounds
Powdered talc	1	pound
Powdered orris	1	pound
Extract of cassie	3	ounces

Barber's Powder.

Corn starch	5	pounds
Precipitated chalk	3	pounds
Powdered talc	2	pounds
Oil of neroli	1	drachm
Oil of cedrat	1	drachm
Oil of orange	2	drachms
Extract of jasmine	1	ounce

Rose Poudre de Riz.

I.

Corn starch	9	pounds
Powdered talc	1	pound
Oil of rose	1¼	drachms
Extract of jasmine	6	drachms

II.

(Cheaper.)

Potato starch	9	pounds
Powdered talc	1	pound
Oil of rose	½	drachm
Extract of jasmine	½	ounce

—Drug. Circ. and Chem. Gaz.

Witch Hazel Toilet Cream (corrected formula) —

Quince seed	90 gr.
Boric acid	8 gr.
Glycerin	4 fl. oz.
Alcohol	6 fl. oz.
Carbolic acid	6 dr.
Cologne water	4 fl. oz.
Oil lavender flowers	40 drops
Glycerite starch	4 av. oz.
Distilled witch hazel extract enough to make	32 fl. oz.

Dissolve the boric acid in 16 ounces of the witch hazel extract, macerate the quince seed in the solution for three hours, strain, add the glycerin, carbolic acid and glycerite, and mix well. Mix the alcohol, cologne water, lavender oil and mucilages, incorporate with the previous mixture and add enough witch hazel extract to bring to the measure of 32 fluid ounces.—Midland Druggist.

TRADE SUGGESTIONS FROM UNITED STATES CONSULS.

Cold Weather and Belated Crops in Germany.—The abnormally cold, wet weather which was noted in these reports during May and June* has continued through July and so far into August as to assume in Germany the character of an impending calamity to the cereal harvests of the year. Until the end of July, the season, although remarkably late, was still hopeful, and the condition of the growing crops on the 15th of June and July was in general quite above that of the preceding year. But as the time came for the wheat and rye to ripen, the cold, wet, cloudy weather kept back the harvest long after the usual date and, when the work of gathering the grain finally began, greatly complicated the task of saving the crops. In many fields, the rye and wheat has been cut and lain in swaths or put up in shocks, exposed to rain and storm, until the grain has been seriously damaged by sprouting. The first samples of the new-crop rye which have been received at the Produce Exchange in Berlin are almost without exception damp, more or less unripe, and, even when artificially dried, of inferior grade. While, therefore, the German grain crop this year will be up to the full average in quantity, its quality has been more or less seriously damaged, and large quantities of rye, which should have been used as breadstuff, will now be distilled or used for feeding animals. It is yet too early to estimate closely the extent of this damage, but accounts from all parts of the empire indicate that it will be considerable. The latest official returns discribe the situation down to August 15 and report that a large part of the wheat and rye of Prussia is still out and in danger. The area of principal crops harvested and growing this year in Prussia, as compared with 1901, offers the following suggestive comparison:

	1902		1901	
	Hectares	Acres.	Hectares	Acres.
Wheat:				
Winter ..	1,036,935	2,562,266	660,099	1,631,104
Spring ..	84,819	209,647	206,705	510,768
Rye:				
Winter ..	4,628,701	11,437,520	4,277,205	10,568,973
Spring ..	69,308	178,109	103,303	255,261
Oats	2,722,777	6,727,981	2,945,440	7,387,182
Potatoes ..	2,223,668	5,500,683	2,292,367	5,664,438
Clover	1,237,146	3,056,987	1,125,107	2,780,149

American Food Products for Malta.—During my temporary sojourn in the United States on leave of absence, I have been receiving numerous letters from merchants at Malta desiring me to execute commissions for them. One of them seems to demand immediate attention, and read in part:

"Will you kindly interest yourself to procure me the agency of some good shippers of codfish, salmon, etc.—not middlemen, but first hands. Also, I wish you would interest some packer to open business relations with me in lard and canned meats; and a firm of cottonseed oil refiners. Can you also induce some fruit merchant to send me a box of samples of your apples? I am sure much can be done in these lines."

With regard to the first item, I would say that Malta is a great consumer of fish. Most of the fish used there is fresh, and is either caught near the islands (in very small quantities) or comes from Tunis or Sicily. Very often there is a scarcity, and I have frequently thought that our salt codfish and even prepared mackerel would find favor. Many years ago, in the time of the sailing vessel, such was the case. Canned salmon is used to a certain extent.

With regard to lard and canned meats, I would say that both these lines of American products are sold there to-day. Cottonseed oil also is in extensive use, with a good demand at all times, but at present it seems to be in the hands of a very few parties.

American apples would, I believe, find a good and permanent demand when once introduced. Malta raises a few apples, but they are of a stunted variety. Our fruit would prove a revelation. The business season of Malta will begin in about a month, and if American houses interested in the above lines will at once take the matter up, there will be a chance to do business in the near future. For good reasons, I am not giving the address of the house desiring these goods; but I am leaving for Malta in a few days, and if communications are sent to me there, I shall take pleasure in handing them to the parties in question, and immediate replies may be expected.

Malta now has direct steamship connection with the United States in the Phelps Mediterranean and New York Steamship Company (a branch of which has now been established a little over three years) and the Levant Line. There are no duties imposed at Malta upon fish or fruit. I shall be pleased to give all assistance possible to those desiring further information.—John H. Grout, Consul at Malta, at Boston.

*Advance Sheets No. 1364; Consular Reports No. 263.

INDEX TO ADVANCE SHEETS OF CONSULAR REPORTS.

No. 1456, September 29.—New Process for Ore Concentration—Tar or Oil for Laying Dust—*Custom-house in Yucatan—*Branch of the Usumi Railroad.

No. 1457, September 30.—Wireless Telegraphy in Germany.

No. 1458, October 1.—*Trade Hints from Guatemala—Metric System in Great Britain—Iron and Cotton Interests in French Colonies—*Demand for American Textiles in Amsterdam.

No. 1459, October 2.—*Promotion of Export Trade in Mexico—Mining in British Columbia—Mining Edict in China—New Railroads in Haiti—*French Demand for Superphosphates.

No. 1460, October 3.—Congress for Protection Against Hail in Lyons.

No. 1461, October 4.—Argentine Trade in 1902—Cotton Cultivation in Egypt—*Imports of Cheese Cloth into Cuba—Dominican Export Regulations—Telephones and Telegraphs in Madeira.

The Reports marked with an asterisk (*) will be published in the SCIENTIFIC AMERICAN SUPPLEMENT. Interested parties can obtain the other Reports by application to Bureau of Foreign Commerce, Department of State, Washington, D. C., and we suggest immediate application before the supply is exhausted.

VALUABLE BOOKS

NOW READY.

Twenty-Third Edition

EXPERIMENTAL SCIENCE.

By GEORGE M. HOPKINS.

Revised and Greatly Enlarged. 2 Octavo Volumes. 1,100 Pages. 900 Illustrations

Cloth Bound, Postpaid, **$5.00.** *Half Morocco, Postpaid,* **$7.00.**

Or Volumes Sold Separately:

Cloth, **$3.00** *per Volume. Half Morocco,* **$4.00** *per Volume.*

EXPERIMENTAL SCIENCE is so well known to many of our readers that it is hardly necessary now to give a description of this work. Mr. Hopkins decided some months ago that it would be necessary to prepare a new edition of this work in order that the many wonderful discoveries of modern times might be fully described in its pages. Since the last edition was published, wonderful developments in wireless telegraphy, for example, have been made. It was necessary, therefore, that a good deal of new matter should be added to the work in order to make it thoroughly up-to-date, and with this object in view some 200 pages have been added. On account of the increased size of the work it has been necessary to divide it into two volumes, handsomely bound in buckram. It may be interesting to note the following additions that have been made to these volumes:

Volume I contains in addition to a large number of simple, well illustrated experiments, a full description of a ¼ H. P. electric motor made expressly for illustration in this edition of "EXPERIMENTAL SCIENCE." It is an ENCLOSED SELF-REGULATING electric motor for a 110 volt circuit. It can be operated by a current from a 110 volt lamp-socket, yielding a full ¼ H. P., or it may be used as a dynamo, furnishing a current capable of operating three 16-candle power, 110 volt incandescent lamps. The construction of the machine is perfect enough to admit of enlarging or reducing its size if desired.

Volume II contains much on the general subject of electricity, besides new articles of great importance. Among these the subject of alternate current machinery is treated. Wireless Telegraphy and Telephony receive attention. Electrical Measuring Instruments, The Electric Clock, The Telegraphone, Experiments in High Voltage, The Nernst Lamp, and Measuring the Heat of the Stars are all thoroughly illustrated and described.

The unprecedented sale of this work shows conclusively that it is the book of the age for teachers, students, experimenters and all others who desire a general knowledge of Physics or Natural Philosophy.

SIXTEENTH REVISED AND ENLARGED EDITION OF 1901

THE SCIENTIFIC AMERICAN

Cyclopedia of Receipts, Notes and Queries

15,000 RECEIPTS. 734 PAGES

Price, **$5** *in Cloth;* **$6** *in Sheep;* **$6.50** *in Half Morocco, postpaid.*

This work has been revised and enlarged. **900 New Formulas.** The work is so arranged as to be of use not only to the specialist, but to the general reader. It should have a place in every home and workshop. A circular containing full Table of Contents will be sent on application. Those who already have the Cyclopedia may obtain the **1901 APPENDIX.** Price, bound in cloth, **$1** postpaid.

The Progress of Invention in the Nineteenth Century.

By EDWARD W. BYRN, A.M.

Large Octavo. 480 Pages. 300 Illustrations. Price **$3** *by Mail, Postpaid. Half Red Morocco, Gilt Top,* **$4.**

The most important book ever published on invention and discovery. It is as readable as a novel, being written in popular style.

The book gives a most comprehensive and coherent account of the progress which distinguishes this as the "golden age of invention," resulting in industrial and commercial development which is without precedent. A chronological calendar of the leading inventions is one of the most important features of the book, enabling the reader to refer at a glance to important inventions and discoveries of any particular year. The book is printed with large type, on fine paper, and is elaborately illustrated with 300 engravings and is attractively bound.

A COMPLETE ELECTRICAL LIBRARY.

By Prof. T. O'CONOR SLOANE.

An inexpensive library of the best books on Electricity. Put up in a neat folding box. For the student, the amateur, the workshop, the electrical engineer, schools and colleges. Comprising five books as follows:

Arithmetic of Electricity, 138 pages	$1.00
Electric Toy Making, 140 pages	1.00
How to Become a Successful Electrician, 180 pages	1.00
Standard Electrical Dictionary, 682 pages	3.00
Electricity Simplified, 158 pages	1.00

Five volumes, 1,301 pages, and over 450 illustrations.

A valuable and indispensable addition to every library.

Our Great Special Offer.—We will send prepaid the above five volumes, handsomely bound in blue cloth, with silver lettering, and inclosed in a neat folding box, at the **Special Reduced Price of $5.00** for the complete set. The regular price of the five volumes is $7.00.

1902 EDITION.

ALL THE WORLD'S FIGHTING SHIPS

By FRED T. JANE, Author of the Naval War Game (Kriegspiel).

Used as a text-book in European navies. The only absolutely correct and complete work of the kind published.

394 PAGES. OVER 3,000 ILLUSTRATIONS.

OBLONG QUARTO. CLOTH. PRICE, $5.00, POST FREE.

CONTAINS:—A photograph of every warship in the world; also a silhouette and a gun and armor diagram of each vessel.

CONTAINS:—The length, beam, draught, horse power, speed, coal supply, number and size of guns, thickness and disposition of armor of every warship in the world.

CONTAINS:—Tables of the size, weight, velocity, energy, penetration, etc., of every gun of every navy in the world.

CONTAINS:—A series of chapters by noted Admirals, Naval Constructors and other experts of various navies, on vital questions of the day in naval construction, tactics, and strategy.

CONTAINS:—A comparative table (by the author) of the strength of the navies of the world—the most scientific attempt yet made to classify the world's warships and navies as to actual fighting strength.

IT SHOULD BE NOTED that this work is from the pen of a naval critic and expert, whose reputation is far-reaching on both sides of the Atlantic. It will be of fascinating interest to those who follow the course of naval development, and as a book of reference should find a place in every library.

MECHANICAL MOVEMENTS,

Powers, Devices, and Appliances.

By GARDNER D. HISCOX, M.E.

A Dictionary of Mechanical Movements, Powers, Devices and Appliances, embracing an illustrated description of the greatest variety of mechanical movements and devices in any language. A new work on illustrated mechanics, mechanical movements, devices and appliances, covering nearly the whole range of the practical and inventive field, for the use of Machinists, Mechanics, Inventors, Engineers, Draughtsmen, Students and all others interested in any way in the devising and operation of mechanical works of any kind.

Large 8vo. 400 pages. 1,549 illustrations. Price **$3.**

☞ *Full descriptive circulars of above books will be mailed free upon application.*

MUNN & CO. Publishers, 361 Broadway N. Y.

THE Scientific American Supplement.

PUBLISHED WEEKLY.

Terms of Subscription, $5 a Year.

Sent by mail, postage prepaid, to subscribers in any part of the United States or Canada. Six dollars a year, sent, prepaid, to any foreign country.

All the back numbers of THE SUPPLEMENT, from the commencement, January 1, 1876, can be had. Price, 10 cents each.

All the back volumes of THE SUPPLEMENT can likewise be supplied. Two volumes are issued yearly. Price of each volume, $2.50 stitched in paper, or $3.50 bound in stiff covers.

COMBINED RATES.—One copy of SCIENTIFIC AMERICAN and one copy of SCIENTIFIC AMERICAN SUPPLEMENT, one year, postpaid, $7.00.

A liberal discount to booksellers, news agents and canvassers.

MUNN & CO., Publishers, 361 Broadway, New York.

TABLE OF CONTENTS.

PAGE

I. CHEMICAL PHYSICS.—History of Cold and the Absolute Zero.—By Prof. JAMES DEWAR. 2402

II. CHEMISTRY.—The Chemical Factor in Human Progress.—I.—By PETER T. AUSTEN, Ph.D., F.C.S. 2408

III. COMMERCE.—Trade Suggestions from United States Consuls... 2412

IV. ELECTRICAL ENGINEERING.—A New Telephone Relay.—1 illustration 2410
Electric Power Installation Near Butte, Montana.—By A. W. CLAPP.—7 illustrations. 2398

V. ELECTRO-CHEMISTRY.—Electrolytic Manufacture of Zinc.... 2399

VI. GEOLOGY.—Volcanoes.—4 illustrations. 2405

VII. MARINE ENGINEERING.—Liquid Fuel for Steamships.—By EDWIN L. ORDE.—17 illustrations. 2400

VIII. MINING AND METALLURGY.—Dredging for Gold. 2405

IX. MISCELLANEOUS.—A Parisian Puppet Theater.—2 illustrations. 2404
An Evil Consequence of the "Pince-Nez." 2407
French Infant Mortality. 2407
Man as a Heat Engine.—By K. SCHREBER. 2407
Selected Formulæ. 2411

X. NATURAL SCIENCE.—The Spider Hunters.—1 illustration. 2400

XI.—TRAVEL AND EXPLORATION.—Personal Narrative by Capt. Sverdrup of His Arctic Trip. 2410

JUST PUBLISHED.

Practical Pointers for Patentees

Containing Valuable Information and Advice on

THE SALE OF PATENTS.

An Elucidation of the best methods Employed by the Most Successful Inventors in Handling Their Inventions.

By F. A. CRESEE, M.E. 144 Pages. Cloth. Price, **$1.00.**

This is the most practical, up-to-date book published in the interest of Patentees, setting forth the best methods employed by the most successful Inventors in handling their patents. It is written expressly for Patentees by a practical Inventor, and is based upon the experience of some of the most successful Inventors of the day.

It gives exactly that information and advice about handling patents that should be possessed by every Inventor who would achieve success by his ingenuity, and will save the cost of many expensive experiments as well as much valuable time in realizing from your inventions. It contains no advertisements of any description, and is published in the interests of the Patentee alone, and its only object is to give him such practical information and advice as will enable him to intelligently handle his patent successfully, economically and profitably.

It gives a vast amount of valuable information along this line that can only be acquired by long, expensive experience in realizing from the monopoly afforded by a patent. *Send for Descriptive Circular.*

MUNN & CO., Publishers, 361 Broadway, New York

The New Supplement Catalogue

Just Published

A large edition of the SUPPLEMENT Catalogue in which is contained a complete list of valuable papers down to the year 1902, is now ready for distribution, free of charge. The new Catalogue is exactly like the old in form, and is brought strictly up to date. All the papers listed are in print and can be sent at once at the cost of ten cents each, to any part of the world. The Catalogue contains 60 three-column pages and comprises 15,000 papers. The Catalogue has been very carefully prepared and contains papers in which information is given that cannot be procured in many text-books published. Write to

MUNN & CO., Publishers, 361 Broadway, New York,

for the new Catalogue.

PATENTS!

MUNN & CO., in connection with the publication of the SCIENTIFIC AMERICAN, continue to examine improvements, and to act as Solicitors of Patents for Inventors.

In this line of business they have had over *fifty years' experience*, and now have *unequaled facilities* for the preparation of Patent Drawings, Specifications, and the prosecution of Applications for Patents in the United States, Canada, and Foreign Countries. Messrs. MUNN & CO. also attend to the preparation of Caveats, Copyrights for Books, Trade Marks, Reissues, Assignments, and Reports on Infringements of Patents. All business intrusted to them is done with special care and promptness, on very reasonable terms.

A pamphlet sent free of charge on application containing full information about Patents and how to procure them; directions concerning Trade Marks, Copyrights, Designs, Patents, Appeals, Reissues, Infringements, Assignments, Rejected Cases, Hints on the Sale of Patents, etc.

We also send, *free of charge*, a Synopsis of Foreign Patent Laws showing the cost and method of securing patents in all the principal countries of the world.

MUNN & CO., Solicitors of Patents,
361 Broadway, New York.

BRANCH OFFICES.—No. 625 F Street, Washington, D. C.

1902.

ment.

r.

s in any
ollars a

rom the
Price,

an like-
yearly.
or $3.50

AMER-
EMENT,

ts and

York.

PAGE
ute 2406
... 2406
... 2412
—I 2410
W. 2410
... 2409
... 2408
by 2400
... 2405
... 2404
... 2407
... 2411
... 2409
y. 2410

ful
.
ent of
y for
ce of
ents
ents
it
the
ally
can
the
ork